CERTIFICATE

I, Hisako ITO, residing at 4-35-13, Takadanobaba, Shinjuku-ku, Tokyo, 169-0075 Japan, hereby certify that I am the translator of the attached document, namely a Certified Copy of Japanese Patent Application No. 2001-006634 and certify that the following is a true translation to the best of my knowledge and belief.

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Signature of Translator

June 30, 2006
Date

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PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of

Satoru KATAGAMI et al.

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For: APPARATUS AND METHOD FOR PRODUCING COLOR FILTERS BY DISCHARGING MATERIAL

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Commissioner for Patents
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Alexandria, VA 22313-1450

Sir:

In accordance with 37 CFR 1.78 (a)(5), and further to the Request for Reconsideration filed June 8, 2006, attached is an accurate translation of Japanese Patent Application No. 2001-006634 filed on January 15, 2001, along with a statement that the translation is accurate.

Should the Examiner believe that anything further would be desirable in order to place this application in even better condition for allowance, the Examiner is invited to contact the undersigned at the telephone number set forth below.

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Attached:
Accurate Translation of Japanese Application No. 2001-006634

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[Name of Document] SPECIFICATION

[Title of the Invention] APPARATUS AND METHOD FOR PRODUCING COLOR FILTER, APPARATUS AND METHOD FOR MANUFACTURING LIQUID CRYSTAL DEVICE, AND APPARATUS AND METHOD FOR MANUFACTURING EL DEVICE

[Claims]

[Claim 1] An apparatus for producing a color filter comprising a plurality of filter elements arranged on a substrate, the apparatus comprising:

a plurality of heads each having a nozzle row comprising an arrangement of a plurality of nozzles;

ink supply means for supplying a filter element material to the heads;

supporting means for supporting the plurality of the heads in a row;

main scanning driving means for moving the supporting means for main scanning; and

sub-scanning driving means for moving the supporting means for sub-scanning;

wherein the supporting means individually supports the plurality of the heads in an inclined state.

[Claim 2] An apparatus for producing a color filter according to Claim 1, wherein the supporting means supports the heads in a fixed state.

[Claim 3] An apparatus for producing a color filter according to Claim 1 or 2, wherein the nozzle rows of the plurality of the heads have substantially the same nozzle pitch, and substantially the same inclination angle.

[Claim 4] An apparatus for producing a color filter comprising a plurality of filter elements arranged on a substrate, the apparatus comprising:

a plurality of heads each having a nozzle row comprising an arrangement of a plurality of nozzles;

ink supply means for supplying a filter element material to the heads;

supporting means for supporting the plurality of the heads in a row;

main scanning driving means for moving the supporting means for main scanning;

sub-scanning driving means for moving the supporting means for sub-scanning;

nozzle row angle control means for controlling the in-plane inclination angles of the plurality of the nozzle rows individually or collectively; and

nozzle row spacing control means for controlling the spacing between the plurality of the nozzle rows individually or collectively.

[Claim 5] An apparatus for producing a color filter according to Claim 4, wherein the nozzle rows of the plurality of the heads have substantially the same nozzle pitch and substantially the same inclination angle.

[Claim 6] A method of producing a color filter comprising a plurality of filter elements arranged on a substrate, the method comprising:

arranging a plurality of heads each having a nozzle row comprising an arrangement of a plurality of nozzles in a sub-scanning direction so that the heads are individually inclined; and

simultaneously moving the heads in a main scanning direction while selectively discharging a filter element material from the plurality of nozzles to form the filter elements on the substrate.

[Claim 7] A method for producing a color filter according to Claim 6, wherein the nozzle rows of the plurality of the heads have substantially the same nozzle pitch, and substantially the same inclination angle.

[Claim 8] An apparatus for manufacturing a liquid crystal device comprising a pair of substrates holding a liquid crystal therebetween, and a plurality of filter elements arranged on at least one of the substrates, the apparatus comprising:

a plurality of heads each having a nozzle row comprising an arrangement of a plurality of nozzles;

ink supply means for supplying a filter element material to the heads;

supporting means for supporting the plurality of the heads in a row;

main scanning driving means for moving the supporting means for main scanning; and

sub-scanning driving means for moving the supporting means for sub-scanning,

wherein the supporting means individually supports the plurality of the heads in an inclined state.

[Claim 9] A method of manufacturing a liquid crystal device comprising a pair of substrates holding a liquid crystal therebetween, and a plurality of filter elements arranged on at least one of the substrates, the method comprising:

arranging a plurality of heads each having a nozzle row comprising an arrangement of a plurality of nozzles in a sub-scanning direction so that the heads are individually inclined; and

simultaneously moving the heads in a main scanning direction while selectively discharging a filter element material from the plurality of nozzles to form the filter elements on the substrate.

[Claim 10] An apparatus for manufacturing an EL device comprising a plurality of picture element pixels each containing an EL luminescent layer and arranged on a substrate, the apparatus comprising:

a plurality of heads each having a nozzle row comprising an arrangement of a plurality of nozzles;

ink supply means for supplying an EL luminescent material to the heads;

supporting means for supporting the plurality of the heads in a row;

main scanning driving means for moving the supporting means for main scanning; and

sub-scanning driving means for moving the supporting means for sub-scanning,

wherein the supporting means individually supports the plurality of the heads in an inclined state.

[Claim 11] A method of manufacturing an EL device comprising a pair of picture element pixels each containing an EL luminescent layer and arranged on a substrates, the method comprising:

arranging a plurality of heads each having a nozzle row comprising an arrangement of a

plurality of nozzles in a sub-scanning direction so that the heads are individually inclined; and

simultaneously moving the heads in a main scanning direction while selectively discharging an EL luminescent material from the plurality of nozzles to form the picture element pixels on the substrate.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to an apparatus and method for producing a color filter used for optical devices such as a liquid crystal device, and the like. The present invention also relates to an apparatus and method for manufacturing a liquid crystal device having a color filter. The present invention further relates to an apparatus and method for manufacturing an EL device using an EL luminescent layer for performing a display.

[0002]

[Description of the Related Art]

Recently, display devices such as a liquid crystal device, an electroluminescence device (referred to as an "EL device"), and the like have been widely used as display sections of electronic apparatuses such as a cell phone, a portable computer, etc. In recent years, also a full-color display by a display device has been increasingly made. A full-color display of a liquid crystal device is made by, for example, transmitting light, which is modulated by a liquid crystal layer, through a color filter. The color filter comprises dot-shaped color filter elements of R (red), G (green) and B (blue) which are formed in a predetermined arrangement such as a stripe, delta, or mosaic arrangement on the surface of a substrate of glass, plastic, or the like.

[0003]

In a full-color display of an EL device, dot-shaped EL luminescent layers of R (red), G (green) and B (blue) colors are provided in a predetermined arrangement, for example, a stripe, delta, or mosaic

arrangement, on the surface of a substrate made of, for example, glass, plastic, or the like, and the EL luminescent layers are held between a pair of electrodes to form picture element pixels. The voltage applied to the electrodes is controlled for each picture element pixel to emit light of a desired color from each pixel, thereby performing a full-color display.

[0004]

It is conventionally known that a photolithography process is used for patterning the filter elements of each of the R, G, and B colors of the color filter, or patterning the pixels of each of the R, G, and B colors of the EL device. However, the use of the photolithography process has the problem of complicating the process, and increasing the cost due to the high consumption of each color material and photoresist, etc.

[0005]

In order to solve the problem, a method has been proposed, in which a filter material, an EL luminescent material, or the like is discharged in a dot shape by an ink jet method to form a dot-arrangement filament or EL luminescent layers, or the like.

[0006]

Consideration will now be given to a case in which as shown in Fig. 22(b), a plurality of dot-shaped filter elements 303 are formed by an ink jet method in each of a plurality of panel areas 302, which are set on the surface of a large-area substrate of glass, plastic, or the like, i.e., a so-called mother board 301 shown in Fig. 22(a). In this case, during several times (twice in the case shown in Fig. 22(b)) of main scanning with an ink jet head 306 having a nozzle row 305 comprising a plurality of nozzles 304 arranged in a row as shown in Fig. 22(c) for each panel area 302, as shown by arrows A1 and A2 in Fig. 22(b), an ink, i.e., a filter material, is discharged from the plurality of nozzles to form the filter elements 303 at desired positions.

[0007]

The filter elements 303 of each of the R, G, and B colors are formed in an appropriate

arrangement such as a stripe, delta or mosaic arrangement. Therefore, for ink discharge from the ink jet head 306, the ink jet head 306 for discharging one of the R, G, and B colors is previously provided for each of the three colors R, G and B so that the ink jet heads 306 are successively used to form an arrangement of the three colors of R, G and B on the mother board 301, as shown in Fig. 22(b).

[0008]

The number of the nozzles provided on the ink jet head 306 is generally about 160 to 180. The mother board 301 generally has a larger area than the ink jet head 306. Therefore, in forming the filter elements 303 on the surface of the mother board 301 by using the ink jet head 306, the ink jet head 306 must be moved several times on the mother board 301 for main scanning while being moved relative to the mother board 301 for sub-scanning to discharge ink during each time of main scanning, drawing a pattern.

[0009]

However, this method has the problem of requiring a long drawing time, i.e., a long time for producing a color filter, because of the large number of times of scanning of the mother board 301 with the ink jet head. In order to solve this problem, the applicant proposed a method in Japanese Application No. 11-279752 in which a plurality of heads are linearly arranged and supported by a supporting member to increase the substantial nozzle number.

[0010]

By using this method, for example, as shown in Fig. 23(a), a plurality of heads 306, e.g., six heads 306, are linearly supported by a supporting member 307, and a plural times of main scanning are performed as shown by arrows A1, A2, ... with movement of the supporting member 307 for sub-scanning in the sub-scanning direction Y, to selectively discharge ink from each of nozzles 304 during each time of main scanning. This method can supply the ink to a wide area by one time of main scanning, thereby certainly shortening the time required for producing a color filter.

[0011]

[Problems to be Solved by the Invention]

In the conventional method shown in Fig. 23(a), each of the heads 306 is arranged in parallel with the sub-scanning direction Y to form a linear nozzle row, and thus the distance between the plurality of the nozzles, i.e., the nozzle pitch, must be the same as the distance between the filter elements 303 on the mother board 301, i.e., the element pitch. However, it is very difficult to form an ink jet head so that the nozzle pitch is the same as the element pitch.

[0012]

A possible method for solving the problem is to incline the supporting member 307 at an angle θ with the sub-scanning direction Y, coinciding the nozzle pitch of the heads 306 with the element pitch on the mother board 301, as shown in Fig. 23(b). However, in this case, a deviation with a dimension Z in the main scanning direction occurs in the nozzle row formed by the heads 306 arranged in a row, thereby causing the problem of increasing the main scanning time for ink discharge by a time corresponding to the deviation. Particularly, in the use of such a six-linked structure heat unit as shown in Fig. 23(b), the deviation has a long dimension because of the long nozzle row, thereby causing the problem of the need to further increase the main scanning time.

[0013]

The present invention has been achieved in consideration of the above problem, and an object of the present invention is to shorten the scanning time of an in ink jet head for forming a pattern of filter elements of a color filter, picture element pixels of an EL device, or the like.

[0014]

[Means for Solving the Problems]

(1) In order to achieve the object, in a first aspect of the present invention, an apparatus for producing a color filter, which comprises a plurality of filter elements arranged on a substrate, comprises a plurality of heads each having a nozzle row comprising an arrangement of a plurality of nozzles, ink supply means for supplying a filter element material to the heads, supporting means for

supporting the plurality of the heads in a row, main scanning driving means for moving the supporting means for main scanning, and sub-scanning driving means for moving the supporting means for sub-scanning, wherein the supporting means individually supports the plurality of heads in an inclined state.

[0015]

In this construction, conceivable examples of the filter element material include colorants of the three primary colors including R (red), G (green), and B (bleu), or C (cyan), Y (yellow) and M (magenta).

[0016]

The apparatus for producing a color filter according to the first aspect of the present invention can discharge ink from the plurality of heads during main scanning of the substrate with the supporting means for supporting the plurality of heads in a row, shortening the scanning time, as compared with scanning of an object surface with a single head.

[0017]

Since scanning is performed with the each of the heads in an inclined state, the nozzle pitch of the nozzles belonging to each of the heads can be coincided with the element pitch of the filter elements formed on the substrate. Furthermore, since each of the heads is inclined, not the entire supporting means, the distance between the nozzle closest to the substrate and the nozzle far from the substrate is shorter than the case in which the entire supporting means is inclined, thereby shortening the scanning time of the substrate with the supporting means. Therefore, the time required for producing a color filter can be shortened.

[0018]

In the apparatus for producing a color filter having the above construction, the supporting means can support the heads in a fixed state, or in a state wherein the inclination angle and/or the head-to-head distance can be changed.

[0019]

In the apparatus for producing a color filter having the above construction, preferably, the nozzle rows of the plurality of the heads have substantially the same nozzle pitch, and substantially the same inclination angle. This can facilitate control for feeding the ink to desired positions.

[0020]

The inclination angles of the nozzle rows are preferably the same in magnitude, but the directions the inclination angles may change between the plus and minus directions. Hereinafter, "substantially the same" means cases including a case in which a great difference does not occur in functions even when a small difference occurs due to error in production.

[0021]

(2) In a second aspect of the present invention, an apparatus for producing a color filter, which comprises a plurality of filter elements arranged on a substrate, comprises a plurality of heads each having a nozzle row comprising an arrangement of a plurality of nozzles; ink supply means for supplying a filter element material to the heads; supporting means for supporting the plurality of the heads in a row; main scanning driving means for moving the supporting means for main scanning; sub-scanning driving means for moving the supporting mechanism for sub-scanning; nozzle row angle control means for controlling the inclination angles of the plurality of nozzle rows individually or collectively, and nozzle row spacing control means for controlling the spacing between the plurality of nozzle rows individually or collectively.

[0022]

In the apparatus for producing a color filter having the above construction, each of the nozzle rows is set in an inclined state by the nozzle row angle control means, thereby obtaining the same effect as the above-described apparatus for producing a color filter according to the first aspect of the present invention.

[0023]

In the apparatus for producing a color filter according to the second aspect of the present

invention, the heads supported by the supporting means can easily be coincided with different element pitches by the function of the nozzle row angle control means. In this case, the distance between the adjacent nozzle rows can be precisely controlled by the function of the nozzle row spacing control means so that the nozzle rows continue with a constant nozzle pitch.

[0024]

The nozzle row angle control means and the nozzle row spacing control means are not limited to special structures, and can be achieved by any structure which can achieve the above-described functions. For example, the nozzle row angle control means can be achieved by a structure in which the heads are mounted on the supporting means so as to be rotatable in a plane, and are connected to a power source such as a pulse motor, a servo motor, or the like, which can control the rotational angle, directly or indirectly through a power transmission mechanism. In this structure, the inclination angle of each of the nozzle rows can be controlled to a desired value by controlling the output angle value of the power source, and the inclination angle of each nozzle row can be kept at the desired value by holding the output shaft of the power source in a lock state after the angles is controlled.

[0025]

The nozzle row spacing control means is also not limited to a special structure, and can be achieved by any structure which can achieve the above-described function. For example, the nozzle row spacing control means can be achieved by a structure in which the in-plane rotation centers of the heads are mounted on the supporting means so as to be slidable, and are connected to reciprocating slide driving means. The reciprocating slide driving means comprises a slide driving device comprising, as a power source, a rotating device such as a pulse motor, a servo motor, or the like, which can control the rotational angle, or a slide driving device comprising a linear driving power source such as a linear motor or the like.

[0026]

In the apparatus for producing a color filter according to the second aspect of the present

invention, preferably, the nozzle rows of the plurality of heads have substantially the same nozzle pitch and substantially the same inclination angles.

[0027]

(3) According to the present invention, a method of producing a color filter, which comprises a plurality of filter elements arranged on a substrate, comprises arranging a plurality of heads each having a nozzle row comprising an arrangement of a plurality of nozzles in a sub-scanning direction so that the heads are individually inclined, and simultaneously moving the heads in a main scanning direction while selectively discharging a filter element material from the plurality of nozzles to form the filter elements on the substrate.

[0028]

In the production method, the plurality of the heads can be simultaneously moved to discharge the ink from each of the heads, thereby shortening the scanning time, as compared with scanning of a substrate surface with a single head.

[0029]

Since main scanning is performed with the heads each of which is in an inclined state, the nozzle pitch of the nozzles belonging to each of the heads can be coincided with the element pitch of the filter elements formed on the substrate. Furthermore, since each of the heads is inclined, not a row of the plurality of heads, the distance between the nozzle closest to the substrate and the nozzle far from the substrate is shorter than the case in which the head row is inclined, thereby shortening the scanning time of the substrate with the plurality of nozzle rows. Therefore, the time required for producing a color filter can be shortened.

[0030]

In the method of producing a color filter having the above construction, preferably, the nozzle rows of the plurality of the heads have substantially the same nozzle pitch and substantially the same inclination angle.

[0031]

(4) According to the present invention, an apparatus for manufacturing a liquid crystal device, which comprises a pair of substrates holding a liquid crystal therebetween, and a plurality of filter elements arranged on at least one of the substrates, comprises a plurality of heads each having a nozzle row comprising an arrangement of a plurality of nozzles, ink supply means for supplying a filter element material to the heads, supporting means for supporting the plurality of the heads in a row, main scanning driving means for moving the supporting mechanism for main scanning, and sub-scanning driving means for moving the supporting mechanism for sub-scanning, wherein the supporting means individually supports the plurality of heads in an inclined state.

[0032]

The apparatus for manufacturing a liquid crystal device can discharge ink, i.e., the filter element material, from the plurality of heads during main scanning of the substrate with the supporting means for supporting the plurality of heads, shortening the scanning time, as compared with scanning of a subject surface with a single head.

[0033]

Since main scanning is performed with the heads each of which is in an inclined state, the nozzle pitch of the nozzles belonging to each of the heads can be coincided with the element pitch of the filter elements formed on the substrate. Furthermore, since each of the heads is inclined, not the entire supporting means, the distance between the nozzle closest to the substrate and the nozzle far from the substrate is shorter than the case in which the entire supporting means is inclined, thereby shortening the scanning time of the substrate with the supporting means. Therefore, the time required for producing a color filter can be shortened.

[0034]

(5) According to the present invention, a method of manufacturing a liquid crystal device, which comprises a pair of substrates holding a liquid crystal therebetween, and a plurality of filter

elements arranged on at least one of the substrates, comprises arranging a plurality of heads each having a nozzle row comprising an arrangement of a plurality of nozzles in a sub-scanning direction so that the heads are individually inclined, and simultaneously moving the heads in a main scanning direction while selectively discharging a filter element material from the plurality of nozzles to form the filter elements on the substrate.

[0035]

The manufacturing method can discharge ink from the plurality of heads while simultaneously moving the plurality of heads for main scanning, shortening the scanning time, as compared with scanning of a subject surface with a single head.

[0036]

Since main scanning is performed with the heads each of which is in an inclined state, the nozzle pitch of the nozzles belonging to each of the heads can be coincided with the element pitch of the filter elements formed on the substrate. Furthermore, since each of the heads is inclined, not a row of the plurality of heads, the distance between the nozzle closest to the substrate and the nozzle far from the substrate is shorter than the case in which the head row is inclined, thereby shortening the scanning time of the substrate with the plurality of nozzle rows. Therefore, the time required for producing a color filter, i.e., the time required for manufacturing a liquid crystal device, can be shortened.

[0037]

(6) According to the present invention, an apparatus for manufacturing an EL device, which comprises a plurality of picture element pixels arranged on a substrate and each containing an EL luminescent layer, comprises a plurality of heads each having a nozzle row comprising an arrangement of a plurality of nozzles, ink supply means for supplying an EL luminescent material to the heads, supporting means for supporting the plurality of the heads in a row, main scanning driving means for moving the supporting mechanism for main scanning, and sub-scanning driving means for moving the

supporting mechanism for sub-scanning, wherein the supporting means individually supports the plurality of heads in a inclined state.

[0038]

The apparatus for manufacturing an EL device can discharge ink, i.e., the EL luminescent material, from the plurality of heads during main scanning of the substrate with the supporting means for supporting the plurality of heads, shortening the scanning time, as compared with scanning of a subject surface with a single head.

[0039]

Since main scanning is performed with the heads each of which is in an inclined state, the nozzle pitch of the nozzles belonging to each of the heads can be coincided with the pixel pitch of the picture element pixels formed on the substrate. Furthermore, since each of the heads is inclined, not the entire supporting means, the distance between the nozzle closest to the substrate and the nozzle far from the substrate is shorter than the case in which the entire supporting means is inclined, thereby shortening the scanning time of the substrate with the supporting means. Therefore, the time required for manufacturing an EL device can be shortened.

[0040]

(7) According to the present invention, A method of manufacturing an EL device, which comprises a plurality of picture element pixels arranged on a substrate and each containing an EL luminescent layer, comprises arranging a plurality of heads each having a nozzle row comprising an arrangement of a plurality of nozzles in a sub-scanning direction so that the heads are individually inclined, and simultaneously moving the heads in a main scanning direction while selectively discharging an EL luminescent material from the plurality of nozzles to form the picture element pixels on the substrate.

[0041]

The manufacturing method can discharge ink, i.e., the EL luminescent material, from the

plurality of heads while simultaneously moving the plurality of heads for main scanning, shortening the scanning time, as compared with scanning of a subject surface with a single head.

[0042]

Since main scanning is performed with the heads each of which is in an inclined state, the nozzle pitch of the nozzles belonging to each of the heads can be coincided with the element pitch of the filter elements formed on the substrate. Furthermore, since each of the heads is inclined, not a row of the plurality of heads, the distance between the nozzle closest to the substrate and the nozzle far from the substrate is shorter than the case in which the head row is inclined, thereby shortening the scanning time of the substrate with the plurality of nozzle rows. Therefore, the time required for manufacturing an EL device can be shortened.

[0043]

[Description of the Embodiments]

(First Embodiment)

A method and apparatus for producing a color filter according to an embodiment of the present invention will be described below. Before the production method and apparatus are described, a color filter produced by the production method is described. Fig. 6(a) schematically shows the planar structure of a color filter according to an embodiment. Fig. 7(d) shows a sectional structure taken along line VII-VII in Fig. 6(a).

[0044]

The color filter 1 of this embodiment comprises a plurality of filter elements 3 which are formed in a dot pattern, which is in this embodiment, a dot matrix, on a surface of a rectangular substrate 2 made of glass, plastic, or the like, and a protecting film 4 laminated on the filter elements 3 as shown in Fig. 7(d). Fig. 6(a) is a plan view of the color filter 1 with the protecting film 4 being removed. Namely, in this embodiment, a color pattern formed by ink jet is illustrated by the filter elements 3.

[0045]

The filter elements 3 are formed by filling colorants in a plurality of rectangular regions, which are arranged in a dot matrix and are divided by a partition 6 made of a non-transmissive resin material and formed in a lattice pattern. Each of the filter elements 3 is made of any one of colorants of R (red), G (green) and B (blue), and the filter elements 3 of each color are arranged in a predetermined pattern. As the arrangement, for example, the stripe arrangement show in Fig. 8(a), the mosaic arrangement shown in Fig. 8(b), and the delta arrangement shown in Fig. 8(c) are known.

[0046]

In the stripe arrangement, all filter elements in each column of a matrix are the same color. In the mosaic arrangement, any three filter elements arranged in a vertical and horizontal lines are respectively R (red), G (green) and B (blue). In the delta arrangement, the filter elements are arranged to be staggered so that any three adjacent filter elements are respectively the three colors of R, G and B.

[0047]

The size of the color filter 1 is, for example, 1.8 inches. The size of each of the filter elements 3 is, for example, 30 μm x 100 μm. The distance between the respective filter elements 3, i.e., the element pitch, is 75 μm, for example.

[0048]

When the color filter 1 of this embodiment is used as an optical element for a full-color display, the three filter elements 3 of the R, G, and B colors are combined as a unit to form a pixel, and light is selectively transmitted through any one of R, G and B or a combination thereof in each pixel to perform a full-color display. In this case, the partition 6 made of a non-transmissive resin material functions as a black matrix.

[0049]

The color filter 1 is cut out of a large-area mother board 12, for example, as shown in Fig. 6(b). Specifically, a patter for one color filter is formed on the surface of each of a plurality of color filter

formation areas 11 set in the mother board 12, cutting grooves are formed around the color filter formation areas 11, and then the mother board 12 is cut along the grooves to form the respective color filters 1.

[0050]

The method and apparatus for producing the color filter 1 shown in Fig. 6(a) will be described below.

[0051]

Fig. 7 schematically shows in order the steps of the method of producing the color filter 1. First, the partition 6 made of a non-transmissive resin material is formed in a lattice pattern on the surface of the mother board 12, as viewed from the direction show by arrow B. The lattice holes 7 of the lattice pattern are areas in which the filter elements 3 are formed, i.e., the filter element areas. Each of the filter element formation areas 7 formed by the partition 6 has planar dimensions of, for example, about 30 μm x 100 μm, as viewed from the direction of arrow B.

[0052]

The partition 6 has the function to prohibit a flow of ink, i.e., a filter element material, supplied to the filter element formation areas 7, and the function as the black matrix. The partition 6 is formed by any desired patterning method, for example, a photolithography method, and is further heated by a heater according to demand.

[0053]

After the partition 6 is formed, droplets 8 of a filter element material are supplied to each of the filter element formation areas 7 to fill each of the filter element areas 7 with a filter element material 13, as shown in Fig. 7(b). In Fig. 7(b), reference numeral 13R denotes the filter element material having R (red) color, reference numeral 13G denotes the filter element material having G (green) color, and reference numeral 13B denotes the filter element material having B (blue) color.

[0054]

After a predetermined amount of the filter element material is supplied to each of the filter element formation areas 7, the mother board 12 is heated to about 70°C by the heater to evaporate the solvent of the filter element materials. The volumes of the filter element materials 13 are decreased by evaporation to planarize the surface, as shown in Fig. 7(c). When the volume is extremely decreased, droplets of the filter element materials are supplied and heated repeatedly until the color filter has a sufficient thickness. By the above-described process, only the solid contents of the filter element materials finally remain to form films, thereby forming the filter elements 3 of each of the desired colors.

[0055]

After the filter elements 3 are formed as described above, heating is carried out at a predetermined temperature for a predetermined time in order to completely dry the filter elements 3. Then, the protecting film 4 is formed by using an appropriate method, for example, a spin coating method, a roll coating method, a dipping method, or the like. The protecting film 4 is formed for protecting the filter elements 3 and for planarizing the surface of the color filter 1.

[0056]

Fig. 9 shows a component device of an apparatus for producing a color filter, i.e., an ink jet apparatus for supplying the filter element materials shown in Fig. 7(b) in accordance with an embodiment. The ink jet apparatus 16 is an apparatus for discharging and adhering the filter element material of one of the colors R, G and B, for example, R color, as ink droplets to a predetermined position in each of the color filter formation areas 11 of the mother board 12 (refer to Fig. 6(b)). Although an ink jet apparatus is prepared for the filter element material of each of the G and B colors, these ink jet apparatuses for the G and B colors are not described below because the structures thereof are the same as Fig. 9.

[0057]

In Fig. 9, the ink jet apparatus 16 comprises a head unit 26 comprising an ink jet head 22, a

head position control device 17 for controlling the position of the ink jet head 22, a board position control device 18 for controlling the position of the mother board 12, a main scanning driving device 19 for moving the ink jet head 22 relative to the mother board 12 for main scanning, a sub-scanning driving device 21 for moving the ink jet head 22 relative to the mother board 12 for sub-scanning, a board feeder 23 for feeding the mother board 12 to a predetermined working position in the ink jet apparatus 16, and a control device 24 for controlling the entirety of the ink jet apparatus 16.

[0058]

The head position control device 17, the board position control device 18, the main scanning driving device 19 and the sub-scanning driving device 21 are provided on a base 9. These devices are covered with a cover 14 according to demand.

[0059]

The ink jet head 22 has a plurality of heads 20, in this embodiment, six heads 20, and a carriage 25 serving as supporting means for supporting the heads 20 arranged in a row, as shown in Fig. 2. The carriage 25 has holes, i.e., recesses, which are slightly larger than the heads 20 and which are formed at supporting positions of the heads 20, so that the heads 20 are respectively placed in the holes, and fixed by screws, an adhesive, or another tightening means. When the positions of the heads 20 relative to the carriage 25 are precisely determined, the heads 20 may be fixed by simply pressing them into the holes, without using special tightening means.

[0060]

Each of the heads 20 has a nozzle row 28 comprising a plurality of nozzles 27 arranged in a row, for example, as shown in Fig. 11. The number of the nozzles 27 is, for example, 180, and the hole diameter of the nozzles 27 is, for example, 28 μm. The nozzle pitch of the nozzles 27 is, for example, 141 μm. In Figs. 6(a) and 6(b), the main scanning direction X of the mother board 12, and the sub-scanning direction Y perpendicular to the main scanning direction X are set as shown in Fig. 11.

[0061]

In Fig. 2, each of the heads 20 is mounted on the carriage 25 so that the nozzle row 28 of each head extends in a direction K0 at an angle θ with the axis line K1 of the carriage 25 in the longitudinal direction. In this embodiment, the ink jet head 22 is positioned so that the axis line K1 of the carriage 25 extends in a direction crossing the main scanning direction X, e.g., in this embodiment, the perpendicular direction, as shown in Fig. 1. Namely, each of the nozzle rows 28 is positioned obliquely at an angle θ with the sub-scanning direction Y perpendicular to the main scanning direction.

[0062]

The ink jet head 22 is moved in parallel with the X direction to perform main scanning of the mother board 12. During this main scanning, the filter element material as an ink is selectively discharged from the plurality of nozzles 27 of each of the heads 20 to adhere the filter element material at predetermined positions in the mother board 12. The ink jet head 22 can be moved by a predetermined distance in the sub-scanning direction, for example, moved by a length corresponding to or larger or shorter than six times the length of the component of each nozzle row 28 in the sub-scanning direction Y, to shift the main scanning position of the ink jet head 22 by the predetermined distance.

[0063]

Each of the heads 20 has an internal structure, for example, shown in Figs. 13(a) and 13(b). Specifically, the head 20 comprises a stainless steel nozzle plate 29, a vibrating plate 31 opposed to the nozzle plate 29, and a plurality of partition members 32 for connecting the nozzle plate 29 and the vibrating plate 31. The partition members 32 form a plurality of ink chambers 33 and a liquid reservoir 34 between the nozzle plate 29 and the vibrating plate 31. The plurality of the ink chambers 33 communicate with the liquid reservoir 34 through passages 38.

[0064]

Also, an ink supply hole 36 is formed at a proper position of the vibrating plate 31, and an ink supply device 37 is connected to the ink supply hole 36. The ink supply device 37 supplies the filter

element material of one of the R, G and B colors, for example, R color, to the ink supply hole 36. The supplied filter element material M is stored in the liquid reservoir 34, and is further passed through the passages 38 to fill the ink chambers 33.

[0065]

The nozzle plate 29 comprises the nozzles 27 for jetting the filter element material M from the ink chambers 33. Furthermore, ink pressing members 39 are provided on the back of the vibrating plate 31, which is opposite to the side forming the ink chambers 33, corresponding to the ink chambers 33. Each of the ink pressing members 39 comprises a piezoelectric element 41, and a pair of electrodes 42a and 42b which hold the piezoelectric element 41 therebetween, as shown in Fig. 13(b). The piezoelectric element 41 is deformed to project outward by electricity supplied to the electrodes 42a and 42b, as shown by an arrow C, increasing the volume of the corresponding ink chamber 33. As a result, an amount of the filter element material M corresponding to the increase in volume flows into the ink chamber 33 from the liquid reservoir 34 through the passage 38.

[0066]

When electrification of the piezoelectric element 41 is stopped, both the piezoelectric element 41 and the vibrating plate 31 return to the initial shapes. As a result, the ink chamber 31 also returns to the initial volume to increase the pressure of the filter element material M in the ink chamber 31, thereby ejecting the filter element M as droplets 8 to the mother board 12 (refer to Fig. 6(b)) from the nozzle 27. In addition, a waste ink layer 43 comprising, for example, a Ni-tetrafluoroethylene eutectoid plated layer is provided around the nozzle 27, for preventing a bend of the flying droplets 8, clogging of the nozzle 27, etc.

[0067]

In Fig. 10, the head position control device 17 comprises a α motor 44 for rotating the ink jet head 22 in a plane, a β motor 46 for oscillating and rotating the ink jet head 22 around an axis parallel to the sub-scanning direction Y, a γ motor 47 for oscillating and rotating the ink jet head 22 around an

axis parallel to the main scanning direction X, and a Z motor 48 for moving the ink jet head 22 in parallel with the vertical direction.

[0068]

In Fig. 10, the board position control device 18 shown in Fig. 9 comprises a table 49 on which the mother board 12 is mounted, and a θ motor 51 for rotating the table 49 in a plane as shown by arrow θ. The main scanning driving device 19 shown in Fig. 9 comprises a guide rail 52 extending in the main scanning direction X, and a slider 53 containing a pulse-driven linear motor. When the linear motor contained in the slider 53 is operated, the slider 53 is moved in parallel with the main scanning direction along the guide rail 52.

[0069]

In Fig. 10, the sub-scanning driving device 21 shown in Fig. 9 comprises a guide rail 54 extending in the sub-scanning direction Y, and a slider 56 containing a pulse-driven linear motor. When the linear motor contained in the slider 56 is operated, the slider 56 is moved in parallel with the sub-scanning direction Y along the guide rail 54.

[0070]

The pulse-driven linear motor contained in each of the slider 53 and the slider 56 can precisely control the rotational angle of the output shaft by a pulse signal supplied to the motor, thereby precisely controlling the position of the ink jet head 22 supported by the slider 53 on the main scanning direction X, the position of the table 49 on the sub-scanning direction, and the like. The position control of the ink jet head 22 and the table 49 is not limited to the method using a pulse motor, and the position control can also be realized by a feedback control method using a servo motor, or any other control method.

[0071]

The board supply device 23 shown in Fig. 9 comprises a board receiving unit 57 for receiving the mother board 12, and a robot 58 for transferring the mother board 12. The robot 58 comprises a

base 59 installed on an installation plane such as a floor, the ground, or the like, an elevating shaft 61 which moves up and down relative to the base 59, a first arm 62 rotating around the elevating shaft 61, a second arm 63 rotating relative to the first arm 62, a suction pad 64 provided at the bottom of the tip of the second arm 63. The suction pad 64 can attract the mother board 12 by air suction, or the like.

[0072]

In Fig. 9, a capping device 76 and a cleaning device 77 are disposed on one side of the sub-scanning driving device 21 in the locus of the ink jet head 22 driven by the main scanning driving device 19 for main scanning. Also, an electronic balance 78 is disposed on the other side. The cleaning device 77 is a device for cleaning the ink jet head 22. The electronic balance 78 is a device for measuring the weight of the ink droplets discharged from each of the nozzles 27 (refer to Fig. 11) of the ink jet head 22. The capping device 76 is a device for preventing the nozzles 27 from being dried when the ink jet head 22 is in a standby state.

[0073]

Furthermore, a head camera 81 is disposed near the ink jet head 22 so as to move together with the ink jet head 22. A board camera 82 supported by a supporting device (not shown in the drawing) provided on the base 9 is disposed at position where the mother board 12 can be photographed.

[0074]

The control device 24 shown in Fig. 9 comprises a computer body 66 containing a processor, a keyboard 67 serving as an input device, and a CRT (Cathode Ray Tube) display 68 serving as a display device. The processor comprises a CPU (Central Processing Unit) 69 for arithmetic processing, and a memory, i.e., an information storage medium 71, for storing various items of information.

[0075]

The head position control device 17, the board position control device 18, the main scanning driving device 19, the sub-scanning driving device 21, and a head driving circuit 72 for driving the piezoelectric elements 41 (refer to Fig. 13(b)) in the ink jet head 22 are connected to the CPU 69

through an input/output interface 73 and a bus 74, as shown in Fig. 14. The board supply device 23, the input device 67, the display 68, the electronic balance 78, the cleaning device 77 and the capping device 76 are also connected to the CPU 69 through the input/output interface 73 and the bus 74.

[0076]

The memory 71 is a concept including semiconductor memory such as RAM (Random Access Memory), ROM (Read Only Memory), and the like, external storage devices such as a head disk, a CD-ROM reader, a disk-type storage medium, and the like. Functionally, there are set a storage area for storing a program software in which the control procedure for operation of the ink jet apparatus 16 is described, a storage area for storing, as coordinate data, the discharge positions of one (for example, R color) of R, G and B in the mother board 12 in order to realize the various RGB arrangements shown in Fig. 8, a storage area for storing an amount of sub-scanning of the mother board 12 in the sub-scanning direction Y shown in Fig. 10, areas functioning as a work area and a temporary file for the CPU 69, and other various areas.

[0077]

The CPU 69 controls the discharge of ink, i.e., the filter element material, at predetermined positions on the surface of the mother board 12 according to the program software stored in the memory 71, and the specific function realizing units include a cleaning operation unit for executing an arithmetic operation for realizing a cleaning process, a capping operation unit for realizing a capping process, a weight measurement operation unit for executing an arithmetic operation for realizing weight measurement using the electronic balance 78 (refer to Fig. 9), and a drawing operation unit for executing an arithmetic operation for drawing a pattern of the filter element material by ink jet.

[0078]

More specifically, the drawing operation unit is divided into various functional operation units such as a drawing start position operation unit for setting the ink jet head 22 at the initial position for drawing, the main scanning control operation unit for executing an arithmetic operation of control for

moving the ink jet head 22 in the main scanning direction X at a predetermined speed, a sub-scanning control operation unit for executing an arithmetic operation of control for shifting the ink jet head 22 in the sub-scanning direction Y by a predetermined amount of sub-scanning, a nozzle discharge control operation unit for executing an arithmetic operation of control for determining which nozzle of the plurality of nozzles of the ink jet head 22 is operated to discharge ink, i.e., the filter element material, etc.

[0079]

In this embodiment, each of the above-descried functions is realized by using the CPU 69 based on the software. However, when each of the functions can be realized by a single electronic circuit without using the CPU, such an electronic circuit can be used.

[0080]

The operation of the ink jet apparatus 16 having the above-described configuration will be described below based on the flowchart shown in Fig. 15.

[0081]

When an operator turns on a power supply to start the ink jet apparatus 16, initialization is first executed in Step S1. Specifically, the head unit 26, the board supply device 23, the control device 24, etc. are set in the predetermined initial state.

[0082]

Next, when a weight measurement time comes ("YES" in Step S2), the head unit 26 is moved to the electronic balance 78 shown in Fig. 9 by the main scanning driving device 19 (Step S3) to measure the weight of the ink discharged from each of the nozzles 27 by using the electronic balance 78 (Step S4). Therefore, the voltage applied to the piezoelectric element 41 corresponding to each of the nozzles 27 is controlled according to the ink discharge properties of the nozzles 27 (Step S5).

[0083]

Next, when a cleaning time comes ("YES" in Step S6), the head unit 26 is moved to the

cleaning device 77 by the main scanning driving device 19 (Step S7) to clean the ink jet head 22 by the cleaning device 77 (Step S8).

[0084]

When the weight measurement time and the cleaning time do not come ("NO" in Steps S2 and S6), or when these processes are finished, the board supply device 23 shown in Fig. 9 is operated to supply the mother board 12 to the table 49 in Step S9. Specifically, the mother board 12 received in the board receiving unit 57 is suctionally held by the suction pad 64, and then the elevating shaft 61, the first arm 62 and the second arm 63 are moved to transfer the mother board 12 to the table 49. Furthermore, the mother board 12 is pressed on positioning pins (refer to Fig. 10) provided at proper positions of the table 49. In order to prevent a positional deviation of the mother board 12 on the table 49, the mother board 12 is preferably fixed to the table 49 by air suction means or the like.

[0085]

Next, the output shaft of the θ motor 51 shown in Fig. 10 is rotated in small angular units to rotate the mother board 12 in small angular units in a plane and position the mother board 12 while observing the mother board 12 with the board camera 82 shown in Fig. 9 (Step S10). Next, the start position of drawing by the ink jet head 22 is determined by an arithmetic operation while observing the mother board 12 by the head camera 81 shown in Fig. 9 (Step S11), and then the main scanning driving device 19 and the sub-scanning driving device 21 are appropriately operated to move the ink jet head 22 to the drawing start position (Step S12).

[0086]

At the same time, the ink jet head 22 is set so that the axis line K1 of the carriage 25 is perpendicular to the main scanning direction X, as shown in Fig. 1. Therefore, the nozzle rows 28 are arranged obliquely at an angle θ with the sub-scanning direction Y of the ink jet head 22. This is a method for geometrically coinciding the dimensional component of the nozzle pitch in the sub-scanning direction Y with the element pitch when the ink jet head 22 is moved in the main scanning

direction X. This is because in a general in jet apparatus, the nozzle pitch corresponding to the distance between the adjacent nozzles 27 is frequently different from the element pitch corresponding to the distance between the adjacent filter elements 3, i.e., the adjacent filter element formation areas 7.

[0087]

When the ink jet head 22 is set at the drawing start position in Step S12 shown in Fig. 15, main scanning is started in the main scanning direction X in Step S13, and at the same time, discharge of ink is started. More specifically, the main scanning driving device 19 shown in Fig. 10 is operated to linearly move the ink jet head 22 in the main scanning direction X shown in Fig. 1 at a constant speed. When the nozzle 27 reach the corresponding filter element formation area 7 to which ink should be supplied during movement, the ink, i.e., the filter element material, is discharged from the nozzle 27 to fill the area 7, forming the filter element 3.

[0088]

When one time of main scanning is completed for the mother board 12 ("YES" in Step S14), the ink jet head 22 returns to the initial position by reverse movement (Step S15). Furthermore, the ink jet head 22 is driven to be moved by the sub-scanning driving device 21 by the predetermined amount of sub-scanning in the sub-scanning direction Y, for example, an amount corresponding to the component of the total length of the six nozzle rows 28 in the sub-scanning direction Y (Step S16). Then main-scanning and ink discharge are repeated to fill the filter element formation areas 7 with the filter element material, forming the filter elements 3 (Step S13).

[0089]

When the operation of drawing the pattern of the filter elements 3 with the ink jet head 22 is completed for the entire area of the mother board 12, as described above ("YES" in Step S17), the mother board 12 after processing is exhausted to the outside by the board supply device 23 or another transfer device in Step S18. Then, the process returns to Step S2 in which the operation of discharging ink of any one of colors R, G and B is repeated for another mother board 12 unless the end of

processing is directed by the operator ("NO" in Step S1).

[0090]

When the operation end is directed by the operator ("YES" in Step S19), the CPU 69 transfers the ink jet head 22 shown in Fig. 9 to the capping device 76 which executes capping of the ink jet head 22 (Step S20).

[0091]

After patterning of one of the three colors of R, G and B, for example, R color, which constitute the color filter, is completed, the mother board 12 is transferred to the ink jet apparatus 16 using the second color of the R, G and B colors, for example, G color, to perform patterning of the G color, and finally transferred to the ink jet apparatus 16 using the third color of the R, G and B colors, for example, B color, to perform patterning of the B color. As a result, the mother board 12 is produced, in which a plurality of the color filters 1 (Fig. 6(a)) having the desired RGB dot arrangement such as the stripe arrangement, or the like are formed. The mother board 12 is cut for each color filter area 11 to produce a plurality of color filters 1.

[0092]

In order to use the color filter 1 for a color display of a liquid crystal device, an electrode, an alignment film, etc. are laminated on the surface of the color filter 1. In this case, when the mother board 12 is cut into the respective color filters 1 before the electrode, the alignment film, etc. are laminated, the subsequent steps of forming the electrode, etc. become very troublesome. Therefore, in this case, the mother board 12 is preferably cut after the necessary addition steps of forming the electrode, the alignment film, etc. are completed, not immediately after the color filters 1 are completed on the mother board 12.

[0093]

As described above, in the method and apparatus for producing a color filter of this embodiment, during main scanning of the substrate 12 with the carriage 25 as supporting means for

supporting the plurality of heads 20 as shown in Fig. 1, ink is discharged from the nozzle rows of the plurality of heads 20. Therefore, the scanning time can be shortened, as compared with scanning of the surface of the substrate 12 with a single head, thereby shortening the time required for producing a color filter.

[0094]

Also, since main scanning is performed with the heads 20 each of which is inclined at an angle with the sub-scanning direction Y, the nozzle pitch of the plurality of nozzles 27 belonging to each of the heads 20 can be coincided with the distance between the filter element formation areas 7, i.e., the element pitch, on the substrate 12. When the nozzle pitch is geometrically coincided with the element pitch, it is advantageous that the positions of the nozzle rows 28 need not be controlled in the sub-scanning direction Y.

[0095]

In this embodiment, the heads 20 are fixed to the carriage 25, and thus one inclination angle θ is set for one carriage 25. Therefore, when the element pitch of the substrate 12 varies, another carriage 25 must be used for realizing the inclination angle θ corresponding to the element pitch.

[0096]

In this embodiment, since the each of the heads 20 is inclined, not the entire carriage 25, the distance T between the nozzle 27 closest to the substrate 12 and the nozzle 27 far from the substrate 12 is shorter than the case in which the entire carriage 25 is inclined, thereby shortening the scanning time of the substrate 12 with the ink jet head 22. Therefore, the time required for producing a color filter can be shortened.

[0097]

In the production apparatus and method of this embodiment, the filter elements 3 are formed by discharging ink from the ink jet head 22, and thus has no need to pass through such a complicated step as a method using a photolithography process, and causes no waste of materials.

[0098]

Although the first embodiment uses the non-transmissive resin material as the partition 6, a light transmitting resin material can also be used as the partition 6. In this case, a light shielding metal film or resin material may be provided at the positions corresponding to the spaces between the respective filter elements, for example, above or below the partition 6, to form a black mask. Alternatively, the partition made of a transmissive resin material may be formed without the black mask being provided.

[0099]

Although the first embodiment uses the filter elements of R, G and B, of course, the filter elements are not limited to R, G and B, and for example, C (cyan), M (magenta), and Y (yellow) may be used. In this case, filter element materials having C, M and Y colors may be used in place of the filter element materials of R, G and B.

[0100]

(Second Embodiment)

Fig. 3 schematically shows a case in which ink, i.e., a filter element material, is discharged into each of the filter element formation areas 7 in the color filter formation areas 11 of the mother board 12 from the ink jet head 22 by a method and apparatus for producing a color filter according to another embodiment of the present invention.

[0101]

The outlines of the steps performed in this embodiment are the same as those shown in Fig. 7, and the ink jet apparatus used for discharging ink is also mechanically the same as the apparatus shown in Fig. 9.

[0102]

This embodiment is different from the embodiment shown in Fig. 1 in that the structure for supporting the heads 20 by the carriage 25 is changed. Specifically, as shown in Fig. 4, each of the

heads 20 is supported by the carriage 25 so as to be rotatable around the axis line K2 of the head 20, i.e., rotatable in a plane, as shown by an arrow N. Each of the heads 20 is also supported by the carriage 25 so as to be slidable, i.e., movable parallel in a plane, as shown by arrow P. Furthermore, the carriage 25 is provided with a nozzle row angle control device 83 and a nozzle row spacing control device 84.

[0103]

The nozzle row angle control device 83 individually or collectively controls the in-plane inclination angles θ of the plurality of nozzle rows 28. The nozzle row angle control device 83 can be formed by any desired structure, for example, a structure in which the heads 20 mounted on the casing 25 so as to be rotatable in a plane as shown by arrow N are connected to a power source such as a pulse motor, a servo motor, or the like, which can control the rotational angle, directly or indirectly through a power transmission mechanism. In this structure, the inclination angle θ of each of the nozzle rows 20 can be controlled to a desired value by controlling the output angle value of the power source, and the inclination angle θ of each nozzle row 20 can be kept at the desired value by holding the output shaft of the power source in a lock state after the angles are controlled.

[0104]

The nozzle row spacing control device 84 individually or collectively controls the spacing between the plurality of nozzle rows 20. The nozzle row spacing control device 84 can be formed by any desired structure, for example, a structure in which the heads 20 mounted on the casing 25 so as to be slidable as shown by arrow P are connected to a slide driving device comprising as a power source a rotating device such as a pulse motor, a servo motor, or the like, which can control the rotational angle, or a slide driving device comprising a linear driving power source such as a linear motor or the like.

[0105]

In this embodiment, the nozzle row angle control device 83 shown in Fig. 4 can be operated to rotate the heads 20 in a plane as shown by arrow N in Fig. 3 to control the in-plane inclination angle θ

of each of the heads 20 so that the nozzle pitch of the nozzle rows 28 coincides with the element pitch of the filter element formation areas 7 on the substrate 12. Furthermore, the nozzle row spacing control device 84 can be operated to control the spacing between the heads 20 shown in Fig. 3 so that the nozzle distance between the ends of the adjacent nozzle rows 28 coincides with the element pitch on the substrate 12.

[0106]

Therefore, a continuous long nozzle row comprising six nozzle rows 28 and having a nozzle pitch coinciding with the element pitch can be formed. In this embodiment, the nozzle pitch of one ink jet head 22 is appropriately controlled to draw a pattern having a different element pitch on the substrate.

[0107]

(Third Embodiment)

Fig. 5 schematically shows a case in which ink, i.e., a filter element material, is discharged to each of the filter element formation areas 7 in the color filter formation areas 11 of the mother board 12 from the ink jet head 22 by a method and apparatus for producing a color filter according to still another embodiment of the present invention.

[0108]

The outlines of the steps performed in this embodiment are the same as these shown in Fig. 7, and the ink jet apparatus used for discharging ink is also mechanically the same as the apparatus shown in Fig. 9.

[0109]

This embodiment is different from the embodiments shown in Figs. 1 and 3 in that the inclination angles of the nozzle rows 28 are the same in magnitude, but alternately change in direction between the plus and minus directions. This method also can form a continuous long nozzle row comprising six nozzle rows 28 and having a nozzle pitch coinciding with the element pitch on the

substrate 12.

[0110]

This embodiment can be formed in a structure in which the nozzle rows 28 are fixed, as shown in Fig. 1, or a structure in which the inclination angles θ and nozzle row spacing between the nozzle rows can be controlled, as shown in Fig. 3.

[0111]

(Fourth Embodiment)

Fig. 12 shows a modified example of the head 20 used in the present invention. The head 20 shown in Fig. 12 is different from the head 20 shown in Fig. 11 in that two nozzle rows 28 are provided in the main scanning direction X. This can supply the filter element material to one filter element formation area 7 from two nozzles 27 formed on the same main scanning line.

[0112]

In this embodiment, the axis line K0 of the ink jet head 22 is inclined at an in-plane inclination angle θ relative to the sub-scanning direction Y. Therefore, the nozzles 27 in the two nozzle rows 28 are preferably shifted from each other, as viewed from the carriage 25, so as to be positioned on the main scanning direction X, not arranged perpendicularly to the axis line K0 of the carriage 25.

[0113]

(Fifth Embodiment)

Fig. 16 shows a further modified example of the head 20 used in the present invention. The head 20 shown in Fig. 16 is different from the head 20 shown in Fig. 11 in that three nozzle rows including a nozzle row 28R for discharging R color ink, a nozzle row 28G for discharging G color ink and a nozzle row 28B for discharging G color ink are formed in the head 20, and the ink discharge system shown in Figs. 13(a) and 13(b) is provided for each of the three nozzle rows. Furthermore, a R ink supply device 37R is connected to the ink discharge system corresponding to the R color nozzle row 28R; a G ink supply device 37G is connected to the ink discharge system corresponding to the G

color nozzle row 28G; and a B ink supply device 37B is connected to the ink discharge system corresponding to the B color nozzle row 28B.

[0114]

The outlines of the steps performed in this embodiment are the same as those shown in Fig. 7, and the ink jet apparatus used for discharging ink is also mechanically the same as the apparatus shown in Fig. 9.

[0115]

In the embodiment shown in Fig. 11, one nozzle row 28 is provided on the head 20, and thus the ink jet head 22 shown in Fig. 2 must be prepared for each of the three colors R, G and B for forming the color filter having three colors R, G and B. On the other hand, in use of the head 20 having the structure shown in Fig. 16, the three colors R, G and B can be simultaneously adhered by one main scanning with the ink jet head 22 comprising a plurality of heads 20 in the X direction, and thus only one ink jet head 22 may be prepared.

[0116]

(Sixth Embodiment)

Fig. 17 shows a manufacturing method using an apparatus for manufacturing a liquid crystal device according to a further embodiment of the present invention. Fig. 18 shows a liquid crystal device manufactured by the manufacturing method according to a further embodiment of the present invention. Fig. 19 shows a sectional structure of the liquid crystal device taken along line X-X in Fig. 18. Before the method and apparatus for manufacturing a liquid crystal device are described, a liquid crystal device manufactured by the manufacturing method is described with reference to an example. The liquid crystal device of the embodiment is a transflective liquid crystal device which performs a full-color display in a single matrix system.

[0117]

In Fig. 18, a liquid crystal device 101 comprises a liquid crystal panel 102, liquid crystal

driving ICs 103a and 103b mounted on the liquid crystal panel 102, a FPC (Flexible Printed Circuit) 104 connected as a wiring connection component to the liquid crystal panel 102, and an illumination device 106 provided as a back light on the back side of the liquid crystal panel 102.

[0118]

The liquid crystal panel 102 is formed by bonding together a first substrate 107a and a second substrate 107b with a sealing material 108. The sealing material 108 is formed by circularly adhering an epoxy resin to the inner surface of the first substrate 107a or the second substrate 107b by, for example, screen printing or the like. The sealing material 108 contains a spherical or cylindrical conductor 109 dispersed therein and made of a conductive material, as shown in Fig. 19.

[0119]

In Fig. 19, the first substrate 107a comprises a plate-like substrate 111a made of transparent glass, transparent plastic, or the like. Also, a reflecting film 112 is formed on the inner surface (the upper surface shown in Fig. 19) of the substrate 111a, an insulating film 113 is laminated on the reflecting film 112, first electrodes 114a are formed in stripes (refer to Fig. 18) on the insulating film 113 as viewed from the direction of arrow D, and an alignment film 116a is formed on the first electrodes 114a. Furthermore, a polarizer plate 117a is mounted on the outer surface (the lower surface shown in Fig. 19) of the substrate 111a by bonding or the like.

[0120]

Although, in Fig. 18, in order to make the arrangement of the first electrodes 114a easy to understand, the stripes of the first electrodes 114a are shown with larger spaces than the actual spaces in a smaller number than the actual number, more first electrodes 114a are actually formed on the substrate 111a.

[0121]

In Fig. 19, the second substrate 107b comprises a plate-like substrate 111b made of transparent glass, transparent plastic, or the like. Also, a color filter 118 is formed on the inner surface (the lower

surface shown in Fig. 19) of the substrate 111b, second electrodes 114b are formed in stripes (refer to Fig. 18) perpendicularly to the first electrodes 114a as viewed from the direction of arrow D, and an alignment film 116b is formed on the second electrodes 114b. Furthermore, a polarizer plate 117b is mounted on the outer surface (the upper surface shown in Fig. 19) of the substrate 111b by bonding or the like.

[0122]

Although, in Fig. 18, like the first electrodes 114a, in order to make the arrangement of the second electrodes 114b easy to understand, the stripes of the second electrodes 114b are shown with larger spaces than the actual spaces, and in a smaller number than the actual number, more second electrodes 114b are actually formed on the substrate 111a.

[0123]

In Fig. 19, a liquid crystal, for example, a STN (Super Twisted Nematic) liquid crystal L, is sealed in the gap, i.e., the cell gap, surrounded by the first substrate 107a, the second substrate 107b and the sealing material 108. Many spherical small spacers 119 are dispersed on the inner surface of the first substrate 107a or the second substrate 107b so that the thickness of the cell gap is maintained by the spacers 119 present in the cell gap.

[0124]

The first electrodes 114a and the second electrode 114b are arranged perpendicularly to each other, and the intersections are arranged in a dot matrix, as viewed from the direction of arrow D in Fig. 19. Each of the intersections of the dot matrix forms one picture element pixel. The color filter 118 comprises components of each of the colors R (red), G (green) and B (blue), which are arranged in a predetermined pattern, for example, a stripe pattern, a delta pattern, or a mosaic pattern, as viewed from the direction of arrow D. The picture element pixels have one-to-one correspondence to the colors R, G and B, and a unit of the picture element pixels of the three colors R, G and B forms a pixel.

[0125]

The plurality of the picture element pixels, i.e., pixels, which are arranged in a dot matrix, are selectively illuminated to display an image of a character, a numeric character, or the like on the outside of the second substrate 107b of the liquid crystal panel 102. The area in which such an image is displayed is an effective pixel area which is shown in a planar rectangular area by an arrow V in Figs. 18 and 19.

[0126]

In Fig. 19, the reflecting film 112 is made of a light reflecting material such as an APC alloy, Al (aluminum), or the like, and an aperture 121 is formed at the position corresponding to each of the picture element pixels at the intersections of the first electrode 114a and the second electrodes 114b. Consequently, the apertures 121 are arranged in the same dot matrix as the picture element pixels, as viewed from the direction of arrow D in Fig. 19.

[0127]

The first electrodes 114a and the second electrodes 114b are made of, for example, a transparent conductive material ITO. Each of the alignment films 116a and 116b is formed by adhering a polyimide resin in a film form having a uniform thickness. The alignment films 116a and 116b are rubbed to determine the initial orientation of the liquid crystal molecules on the surfaces of the first substrate 107a and the second substrate 107b.

[0128]

In Fig. 18, the first substrate 107a is formed in a wider area than the second substrate 107b, and when both substrates are bonded together with the sealing material 108, the first substrate 107a has a substrate overhang 107c overhanging outward from the second substrate 107b. In addition, various types of wiring such as lead wiring 114c extending from the first electrodes 114a, lead wiring 114d connected to the second electrodes 114b on the second substrate 107b through the conductors 109 (refer to Fig. 19) present in the sealing material 108, metal wiring 114e connected to input bumps, i.e., input terminals, of the liquid crystal driving IC 103a, metal wiring 114f connected to input bumps, i.e.,

input terminals, of the liquid crystal driving IC 103b, etc. are formed in an appropriate pattern on the substrate overhang 107c.

[0129]

In this embodiment, the lead wiring 114c extending from the first electrodes 114a and the lead wiring 114d connected to the second electrodes 114b are made of the same material ITO as the electrodes, i.e., a conductive oxide. The metal wirings 114e and 114f serving as input wirings of the liquid crystal driving ICs 103a and 103b are made of a metal material having a low electric resistance value, for example, an APC alloy. The APC alloy mainly contains Ag, and Pd and Cu as additive components, and for example, it is composed of 98% of Ag, 1% of Pd, and 1% of Cu.

[0130]

The liquid crystal driving ICs 103a and 103b are mounted on the surface of the substrate overhang 107c by bonding with an ACF (Anisotropic Conductive Film) 122. Namely, in this embodiment, the liquid crystal panel is a so-called COG (Chip On Glass) type liquid crystal panel having a structure in which a semiconductor chip is mounted directly on a substrate. In the COG type mounting structure, the input-side bumps of the liquid crystal driving ICs 103a and 103b are conductively connected to the metal wirings 114e and 114f, and the output-side bumps of the liquid crystal driving ICs 103a and 103b are conductively connected to the lead wirings 114c and 114d.

[0131]

In Fig. 18, the FPC 104 comprises a flexible resin film 123, a circuit 126 including chip parts 124, and metal wiring terminals 127. The circuit 126 is mounted directly on the surface of the resin film 123 by soldering or another conductive connection means. The metal wiring terminals 127 are made of an APC alloy, Cr, Cu, or another conductive material. The portion of the FPC 104 in which the metal wiring terminals 127 are formed is connected, with the ACF 122, to the portion of the first substrate 107a in which the metal wirings 114e and 114f are formed. The metal wirings 114e and 114f on the substrate side are connected to the metal wiring terminals 127 on the FPC side by the function of

the conductive particles contained in the ACF 122.

[0132]

Furthermore, an external connection terminal 131 is formed at the side of the FPC 104 opposite to the liquid panel side so that the external connection terminal 131 is connected to an external circuit not shown in the drawing. Therefore, the liquid crystal driving ICs 103a and 103b are driven based on the signal transmitted from the external circuit to supply a scanning signal to either the first or second electrodes 114a and 114b, a data signal being supplied to the other electrodes. As a result, the voltage of each of the picture element pixels arranged in the dot matrix in the effective display area V is controlled for each pixel, and thus the orientation of the liquid crystal L is controlled for each picture element pixel.

[0133]

In Fig. 18, the illumination device 106 functioning as the so-called back light comprises a photoconductor 132 composed of an acrylic resin, a diffusion sheet 133 provided on the light emission plane 132b of the photoconductor 132, a reflecting sheet 134 provided on the plane of the photoconductor 132 opposite to the light emission plane 132b, and a LED (Light Emitting Diode) 136 serving as a light emission source, as shown in Fig. 19.

[0134]

The LED 136 is supported by an LED substrate 137 which is mounted on a supporting member (not shown in the drawing), for example, which is formed integrally with the photoconductor 132. By mounting the LED substrate 137 at the predetermined position of the supporting member, the LED 136 is located at the position opposite to the light incidence plane 132a of the photoconductor 132, which is a side surface thereof. Reference numeral 138 denotes a buffer for buffering an impact applied to the liquid crystal panel 102.

[0135]

When the LED 136 emits light, the light is incident on the light incidence plane 132a,

introduced into the photoconductor 132, and transmitted therethrough while being reflected by the reflecting sheet 134 and the wall surfaces of the photoconductor 132. During transmittance, the light is emitted as flat light to the outside from the light emission plane 132b through the diffusion sheet 133.

[0136]

In the liquid crystal device 101 of this embodiment having the above-described construction, therefore, with sufficiently bright external light such as sunlight, room light, or the like, the external light is introduced into the liquid crystal panel 102 from the second substrate 107b, transmitted through the liquid crystal L, and then reflected by the reflecting film 112 to be again supplied to the liquid crystal L. The orientation of the liquid crystal L is controlled for each of the picture element pixels of R, G and B by the electrodes 114a and 114b holding the liquid crystal L therebetween, and thus the light supplied to the liquid crystal L is modulated for each picture element pixel. By modulation, light transmitted through the polarizer plate 117b and light not transmitted through the polarizer plate 117b form an image such as a character, a numeric character, or the like on the outside of the liquid crystal panel 102. As a result, a reflective display is performed.

[0137]

On the other hand, with an insufficient quantity of external light, light emitted from the LED 136 is emitted as flat light from the light emission plane 132b of the photoconductor 132, and the light is supplied to the liquid crystal L through the apertures formed in the reflecting film 112. Like in the reflective display, in this case, the supplied light is modulated for each picture element pixel by the liquid crystal L with the controlled orientation, thereby displaying an image on the outside. As a result, a transmissive display is performed.

[0138]

The liquid crystal device 101 having the above construction is manufactured by, for example, the manufacturing method shown in Fig. 17. In this manufacturing method, a series of steps from step P1 to step P6 are steps of forming the first substrate 107a, and a series of steps from step P11 to step

P14 are steps of forming the second substrate 107b. The first substrate forming process and the second substrate forming process are separately carried out.

[0139]

First, the first substrate forming process is described. The reflecting film 112 for a plurality of liquid crystal panels 102 is formed on the surface of a large-area mother raw material base made of light transmitting glass, light transmitting plastic, or the like by the photolithography method, and the insulating film 113 is formed on the reflecting film 112 by a known deposition method (Step P1). Next, the first electrodes 114a and the wirings 114c, 114d, 114e and 114f are formed by the photolithography process (Step P2).

[0140]

Next, the alignment film 116a is formed on the first electrodes 114a by coating, printing, or the like (Step P3), and then the alignment film 116a is rubbed to determine the initial orientation of the liquid crystal (Step P4). Next, the sealing material 108 is circularly formed by, for example, screen printing or the like (Step P5), and then the spherical spacers 119 are dispersed on the sealing material 108 (Step P6). As a result, a large-area mother first substrate is formed, in which a plurality of panel patterns are formed on the first substrates 107a of the liquid crystal panels 102.

[0141]

The second substrate forming process (Step P11 to Step P14 shown in Fig. 18) is carried separately from the first substrate forming process. First, a large-area mother raw material base made of light transmitting glass, light transmitting plastic, or the like is prepared, and the color filter 118 for a plurality of the liquid crystal panels 102 is formed on the surface of the mother raw material base (Step P11). The color filter is formed by the production method shown in Fig. 7, in which the filter elements of each of the R, G and B colors are formed by using the ink jet apparatus 16 shown in Fig. 9 according to any one of the methods of controlling an ink jet head shown in Figs. 1, 2, 3, 4, and 5. The method of producing a color filter, and the method of controlling an ink jet head are the same as described above,

and description thereof is thus omitted.

[0142]

As shown in Fig. 7(d), the color filter 1, i.e., the color filter 118 is formed on the mother board 12, i.e., the mother raw material base. Then, the second electrodes 114b are formed by the photolithography process (Step P12), and the alignment film 116b is formed by coating, printing, or the like (Step P13). Then, the alignment film 116b is rubbed to determine the initial orientation of the liquid crystal (Step P14). As a result, a large-area mother second substrate is formed, in which a plurality of panel patterns are formed on the second substrates 107b of the liquid crystal panels 102.

[0143]

After the large-area mother first and second substrates are formed as described above, both mother boards are aligned with each other with the sealing material 108 provided therebetween, and then bonded together (Step P21). As a result, an empty panel structure containing a panel portion for a plurality of liquid crystal panels is formed with no liquid crystal sealed therein.

[0144]

Next, scribe grooves, i.e., cutting grooves, are formed at predetermined positions of the completed empty panel structure, and then the panel structure is broken, i.e., cut, based on the scribe grooves (Step P22). Consequently, a strip-like empty panel structure is formed, in which a liquid crystal inlet opening 110 (refer to Fig. 18) of the sealing material 108 of each of the liquid crystal panels is exposed to the outside.

[0145]

Then, the liquid crystal L is injected into the liquid crystal panel through the exposed liquid crystal inlet opening 110, and then the liquid crystal inlet opening 110 is sealed with a resin or the like (Step P23). The liquid crystal is generally injected by, for example, a method in which a storage reservoir in which the liquid crystal is stored, and the strip-like empty panel are placed in a chamber, the strip-like empty panel is dipped in the liquid crystal in the chamber after the chamber is put into a

vacuum state, and then the chamber is opened to the atmospheric pressure. At this time, the inside of the empty panel is in a vacuum state, and thus the liquid crystal pressurized by the atmospheric pressure is introduced into the panel through the liquid crystal inlet opening. Since the liquid crystal adheres to the surfaces of the liquid crystal panel structure after being injected in the panel structure, the strip-like panel is cleaned in Step P24 after the liquid crystal is injected.

[0146]

Then, after injection of the liquid crystal and cleaning, scribe grooves are again formed at predetermined positions of the strip-like mother panel, and then the strip-like panel is cut based on the scribe grooves to be cut into a plurality of liquid crystal panels 102 (Step P25). Then, as shown in Fig. 18, the liquid crystal driving ICs 103a and 103b are mounted on each of the thus-produced liquid crystal panels 102, the illumination device 106 is mounted as a back light, and the FPC 104 is connected to the panel 102 to complete the intended liquid crystal device 101 (Step P26).

[0147]

The above-described method and apparatus for manufacturing a liquid crystal device are characterized by, particularly, the step of producing the color filter as described below. Namely, an ink jet head having the structure shown in Figs. 1, 2, 3, 4 or 5 is used for discharging ink from the nozzle rows 28 of the plurality of heads 20 during main scanning of the substrate 12 with the carriage 25 serving as supporting means for supporting the plurality of heads 20. Therefore, the scanning time can be shortened as compared with the case of scanning of the surface of the substrate 12 with one head, thereby shortening the time required for producing a color filter.

[0148]

Since main scanning is performed with the heads 20 each of which is inclined at an angle θ with the sub-scanning direction Y, the nozzle pitch of the plurality of nozzles 27 belonging to each of the heads 20 can be coincided with the distance between the filter element formation areas 7, i.e., the element pitch, on the substrate 12. When the nozzle pitch can be geometrically coincided with the

element pitch, the positions of the nozzle rows 28 desirably need not be controlled in the sub-scanning direction Y.

[0149]

Also, the entire carriage 25 is not inclined, but the each of the heads 20 is inclined, the distance between the nozzle closest to the substrate 12 and the nozzle far from the substrate 12 is shorter than the case in which the entire carriage 25 is inclined, thereby shortening the scanning time of the substrate 12 with the ink jet head 22. Therefore, the time required for producing a color filter can be shortened.

[0150]

In the method and apparatus for manufacturing a liquid crystal device of this embodiment, the filter elements 3 are formed by ink discharge from the ink jet head 22, thereby causing no need to pass through such a complicated process as the use of the photolithography process and no waste of materials.

[0151]

(Eighth Embodiment)

Fig. 20 shows a manufacturing method using an apparatus for manufacturing an EL device according to an embodiment of the present invention. Fig. 21 shows the main steps of the manufacturing method and a main sectional structure of a finally resulted EL device. As shown in Fig. 21(d), an EL device 201 comprises pixel electrodes 202 formed on a transparent substrate 204; a bank 205 formed in a lattice shape as viewed from the direction of arrow G to be located between the respective pixel electrodes 202; a hole injection layer 220 formed in recesses arranged in a a lattice; a R color luminescent layer 203R, a G color luminescent layer 203G and a B color luminescent layer 203B which are formed in recesses arranged in a predetermined lattice arrangement such as a stripe arrangement as viewed from the direction of arrow G; and a counter electrode 213 formed on the luminescent layers.

[0152]

When each of the pixel electrodes 202 is driven by a two-terminal active element such as a TFD (Thin Film Diode) element or the like, the counter electrodes 213 are formed in stripes as viewed from the direction of arrow G. When each of the pixel electrodes 202 is driven by a three-terminal active element such as a TFT (Thin Film Transistor) element or the like, the counter electrodes 213 are formed as a single planar electrode.

[0153]

The area held between each of the pixel electrodes 202 and each of the counter electrodes 213 serves as a picture element pixel, and a unit of the three picture element pixels of R, G and B colors forms a pixel. By controlling a current flowing through each of the picture element pixels, light is selectively emitted from a desired pixel of the plurality of picture element pixels to display a desired full-color image in the direction of arrow H.

[0154]

The EL device 201 is manufactured by, for example, the manufacturing method shown in Fig. 20.

Namely, in Step P51, as shown in Fig. 21(a), active elements such as TFD element, TFT elements, or the like are formed on the surface of the transparent substrate 204, and the pixel electrodes 202 are further formed. As the forming method, for example, a photolithography method, a vacuum deposition method, a sputtering method, a pyrosol method, or the like can be used. As the material of the pixel electrodes, ITO (Indium Tin Oxide), tin oxide, a compound oxide of indium oxide and zinc oxide, or the like can be used.

[0155]

Next, in Step P52, as shown in Fig. 20(a), a partition, i.e., the bank 205, is formed by a puttering method, for example, a photolithography method, to fill the spaces between the respective transparent electrodes 202. This can improve contrast, and prevent color mixing of luminescent

materials and light leakage from the spaces between the pixels. Although the material of the bank 205 is not limited as long as it has durability against a solvent of the EL materials, an organic material which can be fluorinated by fluorocarbon gas plasma treatment, for example, an acrylic resin, an epoxy resin, photosensitive polyimide, or the like is preferably used.

[0156]

Next, the substrate 204 is continuously treated with oxygen gas plasma and fluorocarbon gas plasma immediately before ink for the hole injection layer is coated (Step P53). This treatment can make a polyimide surface water-repellant and an ITO surface hydrophilic, thereby controlling wettability of the substrate for finely patterning ink jet droplets. As the device for generating a plasma, either a device for generating a plasma in vacuum or a device for generating a plasma in the air may be used in a same manner.

[0157]

Next, in Step P54, as shown in Fig. 21(a), the ink for the hole injection layer is discharged from the ink jet head 22 of the ink jet apparatus 16 shown in Fig. 9, and coated in a pattern on the pixel electrodes 202. Specifically, the ink jet head controlling method shown in Fig. 1, 2, 3, 4 or 5 is used. After coating, the solvent is removed under a vacuum (1 torr) at room temperature for 20 minutes (Step P55), and then heat treatment is performed in the air at 20°C (on a hot plate) for 10 minutes to form the hole injection layers 220 incompatible with ink for luminescent layers (Step P56). The thickness of the hole injection layers 220 is 40 nm.

[0158]

Next, in Step P57, as shown in Fig. 21(b), ink for the R color luminescent layer and ink for the G color luminescent layer are coated on the hole injection layer in each of the filter element areas by using an ink jet process. In this process, the ink for each luminescent layer is discharged from the ink jet head of the ink jet apparatus 16 shown in Fig. 9, and the ink jet controlling method is performed according to the method shown in Fig. 1, 2, 3, 4 or 5. The ink jet process can easily finely pattern ink

within a short time. The thickness can be changed by changing the solid content of an ink composition and the discharge amount.

[0159]

After coating of the inks for luminescent layers, the solvent is removed under a vacuum (1 torr) at room temperature for 20 minutes (Step P58), and then the inks are conjugated by heat treatment in a nitrogen atmosphere at 150°C for 4 hours to form the R color luminescent layer 203R and the G color luminescent layer 203G (Step P59). The thickness of the luminescent layers is 50 nm. The luminescent layers conjugated by heat treatment are insoluble in a solvent.

[0160]

The hole injection layer 220 may be continuously treated with oxygen gas plasma, and fluorocarbon plasma before the luminescent layers are formed. This can form a fluorinated layer on the hole injection layer 220 to increase the efficiency of hole injection due to an increase in ionization potential, thereby providing an organic EL device having a high efficiency of light emission.

[0161]

Next, in Step P60, as shown in Fig. 21(c), the B color luminescent layer 203B is formed on the R color luminescent layer 203R, the G color luminescent layer 203G and the hole injection layer 220 in each of the picture element pixels. This can not only form the primary colors R, G and B, but also remove the steps between the R color luminescent layers 203R and the G color luminescent layers 203G, and the bank 205 to planarize the surface. Therefore, short-circuiting between the upper and lower electrodes can be securely prevented. By controlling the thickness of the B color luminescent layers 203B, the B color luminescent layers function as electron injection transport layers in a laminated structure comprising the R color luminescent layers 203R and the G color luminescent layers 203G, thereby emitting no B color light.

[0162]

As the method of forming the B color luminescent layers 203B as described above, for

example, a general spin coating method as a wet method, or the same ink jet method as that for forming the R color luminescent layers 203R and the G color luminescent layers 203G can be used.

[0163]

Then, in Step P61, as shown in Fig. 21(d), the counter electrodes 213 are formed to produce the intended EL device 201. When the counter electrodes 213 are formed as a planar electrode, the electrodes can be formed by a deposition method such as evaporation, sputtering, or the like using, for example, Mg, Ag, Al, Li, or the like as a material. When the counter electrodes 213 are formed as stripe electrodes, the electrodes can be formed by patterning a deposited electrode layer by photolithography or the like.

[0164]

In the above-described method and apparatus for manufacturing an EL device, an ink jet head having the structure shown in Figs. 1, 2, 3, 4 or 5 is used for discharging ink from the nozzle rows 28 of the plurality of heads 20 during main scanning of the substrate 12 with the carriage 25 serving as supporting means for supporting the plurality of heads 20. Therefore, the scanning time can be shortened as compared with the case of scanning of the surface of the substrate 12 with one head, thereby shortening the time required for producing an EL device.

[0165]

Since main scanning is performed with the heads 20 each of which is inclined at an angle θ with the sub-scanning direction Y, the nozzle pitch of the plurality of nozzles 27 belonging to each of the heads 20 can be coincided with the distance between the filter element formation areas 7, i.e., the element pitch, on the substrate 12. When the nozzle pitch can be geometrically coincided with the element pitch, the positions of the nozzle rows 28 desirably need not be controlled in the sub-scanning direction Y.

[0166]

Also, the entire carriage 25 is not inclined, but the each of the heads 20 is inclined, the distance

between the nozzle closest to the substrate 12 and the nozzle far from the substrate 12 is shorter than the case in which the entire carriage 25 is inclined, thereby shortening the scanning time of the substrate 12 with the ink jet head 22. Therefore, the time required for producing an EL device can be shortened.

[0167]

In the manufacturing method and apparatus of this embodiment, the picture element pixels 3 are formed by ink discharge from the ink jet head 22, thereby causing no need to pass through such a complicated process as the use of the photolithography process and no waste of materials.

[0168]

(Other embodiments)

Although the present invention is described above with reference to the preferred embodiments, the present invention is not limited to the embodiments, and various modifications can be made within the scope of the claim of the present invention.

[0169]

For example, in the above-described embodiments, six heads 20 are provided in the ink jet head 22 as shown in Fig. 1, the number of the heads 20 can be decreased or increased.

[0170]

In the embodiment shown in Fig. 1, plural lines of the color filter formation areas 11 are set on the mother board 12, the present invention can be applied to the case in which one line of the color filter formation areas 11 is formed on the mother board 12. Also, the present invention can be applied to the case in which only one color filter formation area 11, whose size is substantially the same as or extremely smaller than the mother board 12, is set on the mother board 12.

[0171]

In the apparatus producing a color filter shown in Figs. 9 and 10, the ink jet head 22 is moved in the X direction to perform main scanning of the substrate 12, and the substrate 12 is moved in the Y

direction by the sub-scanning driving device 21 to perform sub-scanning of the substrate 12 with the ink jet head 22. However, in contrast, the substrate 12 may be moved in the Y direction to execute main scanning, and the ink jet head 22 may be moved in the X direction to execute sub-scanning.

[0172]

Although each of the above-described embodiments uses an ink jet head having a structure in which ink is discharged by utilizing deflection of a piezoelectric element, an ink jet head having any desired structure can be used.

[0173]

[Advantage of the Invention]

In the apparatuses and methods for producing each of a color filter, a liquid crystal device, and an EL device of the present invention, ink is discharged from a plurality of heads during main scanning of a substrate with the plurality of heads. Therefore, the scanning time can be shortened as compared with the case of scanning of the surface of the substrate with one head.

[0174]

Since main scanning is performed with the heads each of which is inclined, the nozzle pitch of the plurality of nozzles belonging to each of the heads can be coincided with the element pitch of filter elements or picture element pixels formed on the substrate.

[0175]

Furthermore, the entire supporting means for supporting the plurality of heads is not inclined, but the each of the heads is inclined, the distance between the nozzle closest to the substrate and the nozzle far from the substrate is shorter than the case in which the entire supporting means is inclined, thereby shortening the scanning time of the substrate with the supporting mechanism. Therefore, the time required for producing a color filter, a liquid crystal device, or an EL device can be shortened.

[Brief Description of the Drawings]

[Fig. 1]

Fig. 1 is a plan view schematically showing a main step of a production method using an apparatus for producing a color filter according to an embodiment of the present invention.

[Fig. 2]

Fig. 2 is a perspective view of the ink jet head shown in Fig. 1.

[Fig. 3]

Fig. 3 is a plan view of schematically showing a main step of a production method using an apparatus for producing a color filter according to another embodiment of the present invention.

[Fig. 4]

Fig. 4 is a perspective view of the ink jet head shown in Fig. 3.

[Fig. 5]

Fig. 5 is a plan view of schematically showing a main step of a production method using an apparatus for producing a color filter according to still another embodiment of the present invention.

[Fig. 6]

Fig. 6(a) is a plan view showing a color filter according to an embodiment of the present invention, and Fig. 6(b) is a plan view showing a mother board serving as a base of the color filter according to an embodiment of the present invention.

[Fig. 7]

Fig. 7 is a sectional view schematically showing the steps for producing a color filter, taken along line VII-VII in Fig. 6(a).

[Fig. 8]

Fig. 8 is a drawing showing examples of arrangement of picture element pixels of the three colors R, G and B in a color filter.

[Fig. 9]

Fig. 9 is a perspective view showing an ink jet apparatus according to an embodiment of the present invention, which is a main component of each of manufacturing apparatuses such as an

apparatus for producing a color filter of the present invention, an apparatus for manufacturing a liquid crystal device of the present invention, and an apparatus for manufacturing an EL device of the present invention.

[Fig. 10]

Fig. 10 is an enlarged perspective view showing a main portion of the apparatus shown in Fig. 9.

[Fig. 11]

Fig. 11 is a perspective view showing a head provided in the ink jet head shown in Fig. 1.

[Fig. 12]

Fig. 12 is a perspective view showing a modified example of a head.

[Fig. 13]

Fig. 13 is a drawing showing the internal structure of a head, in which Fig. 13(a) is a partially cut-away perspective view, and Fig. 13(b) is a sectional view taken along line J-J in Fig. 13(a).

[Fig. 14]

Fig. 14 is a block diagram showing en electric control system used in the ink jet head apparatus shown in Fig. 9.

[Fig. 15]

Fig. 15 is a flowchart showing a flow of control executed by the control system shown in Fig. 14.

[Fig. 16]

Fig. 16 is a perspective view showing another modified example of a head.

[Fig. 17]

Fig. 17 is a drawing showing the steps of a method of manufacturing a liquid crystal device according to an embodiment of the present invention.

[Fig. 18]

Fig. 18 is an exploded perspective view showing an example of a liquid crystal device manufactured by the method of manufacturing a liquid crystal device of the present invention.

[Fig. 19]

Fig. 19 is a sectional view showing the sectional structure of the liquid crystal device taken along line X-X in Fig. 18.

[Fig. 20]

Fig. 20 is a drawing showing the steps of a method of manufacturing an EL device according to an embodiment of the present invention.

[Fig. 21]

Fig. 21 is a sectional view of the EL device corresponding to the steps shown in Fig. 20.

[Fig. 22]

Fig. 22 is a drawing showing an example of a conventional method of producing a color filter.

[Fig. 23]

Fig. 23 is a drawing showing another example of a conventional method of producing a color filter.

[Reference Numerals]

1 color filter

2 substrate

3 filter element

4 protecting film

6 partition

7 filter element formation area

11 color filter formation area

12 mother board

13 filter element material

16 ink jet apparatus

17 head position controlling device

18 board position controlling device

19 main scanning driving device (main scanning driving means)

20 head

21 sub-scanning driving device (sub-scanning driving means)

22 ink jet head

25 carriage (supporting means)

26 head unit

27 nozzle

28 nozzle row

37 ink supply device (ink supply means)

39 ink pressure member

41 piezoelectric element

49 table

76 capping device

77 cleaning device

78 electronic balance

81 head camera

82 board camera

83 nozzle row angle control device (nozzle row angle control means)

84 nozzle row spacing control device (nozzle row spacing control means)

101 liquid crystal device

102 liquid crystal panel

107a, 107b substrate

111a, 111b base

114a, 114b electrode

118 color filter

201 EL device

202 pixel electrode

203R, 203G, 203B luminescent layer

204 substrate

205 bank

213 counter electrode

220 hole injection layer

L liquid crystal

M filter element material

X main scanning direction

Y sub-scanning direction

[Name of Document] ABSTRACT

[Abstract]

[Object] To shorten the scanning time with an ink jet head for forming a pattern of filter elements of a color filter, picture element pixels of an EL device, or the like.

[Solving Means] An apparatus for producing a color filter including a plurality of filter elements arranged on a substrate. The apparatus includes a plurality of heads 20 each having a nozzle row 28 having a plurality of nozzles 27 arranged, an ink supply device for supplying a filter element material to the heads 20, a carriage 25 supporting the heads 20 arranged thereon, a main scanning driving device for moving the carriage 25 for main scanning in the X direction, and a sub-scanning driving device for moving the carriage 25 for sub-scanning in the Y direction. The carriage 25 supports the plurality of heads 20 each of which is inclined at an in-plane inclination angle θ.

[Selected Figure] Fig. 1

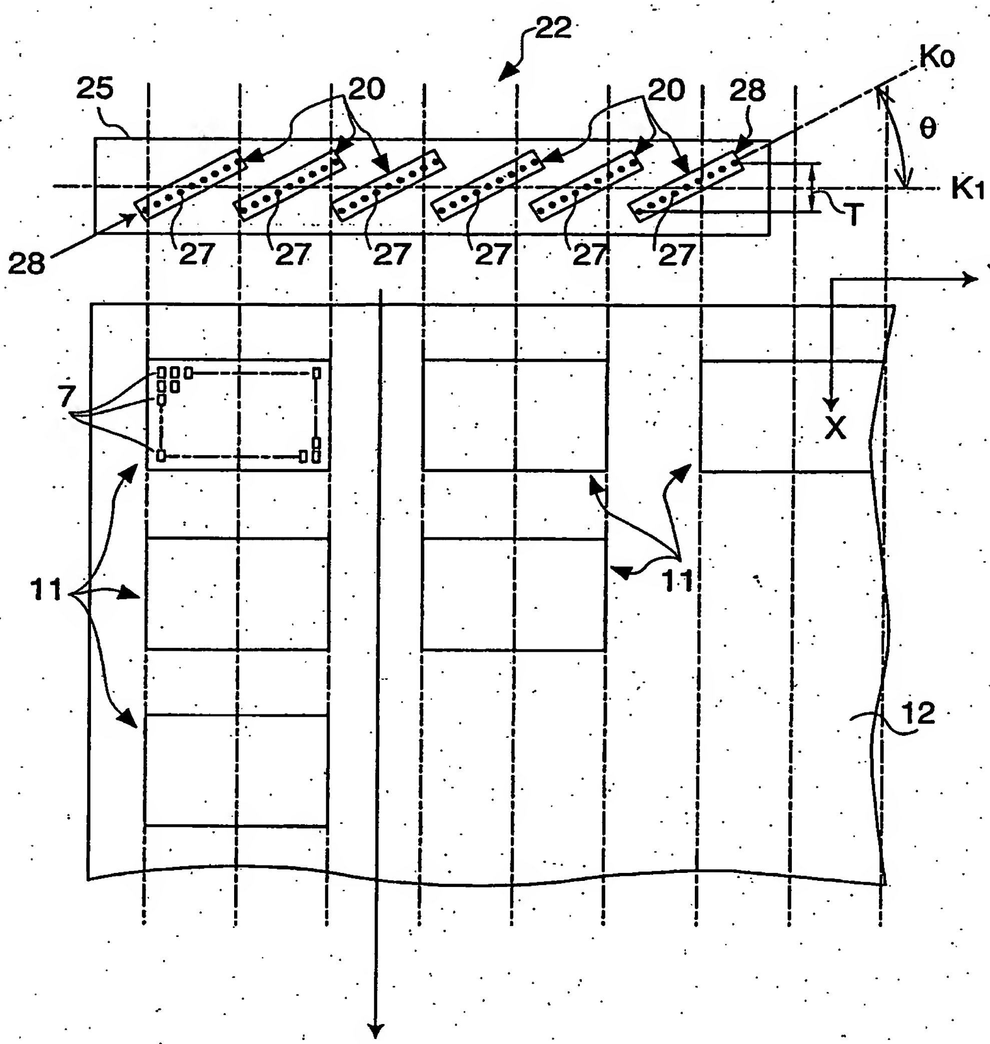


FIG. 1

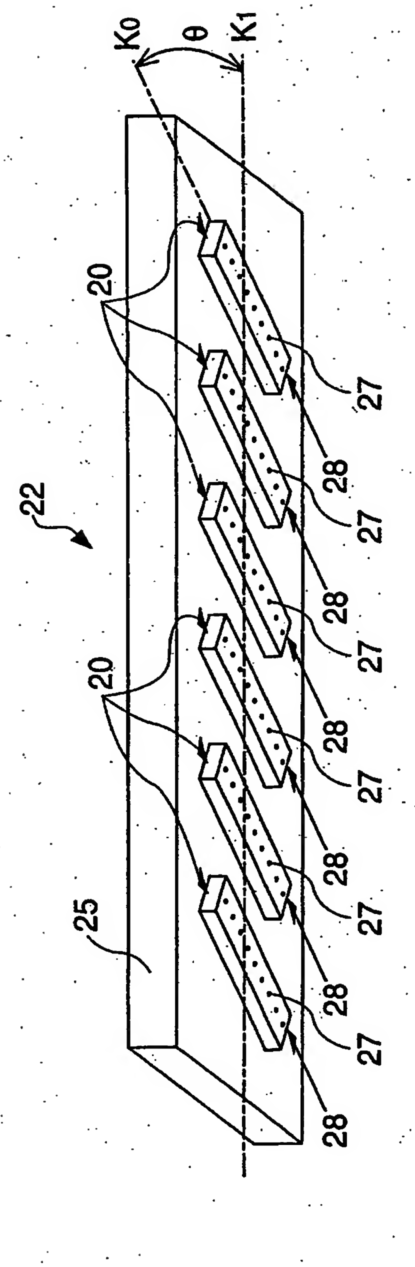
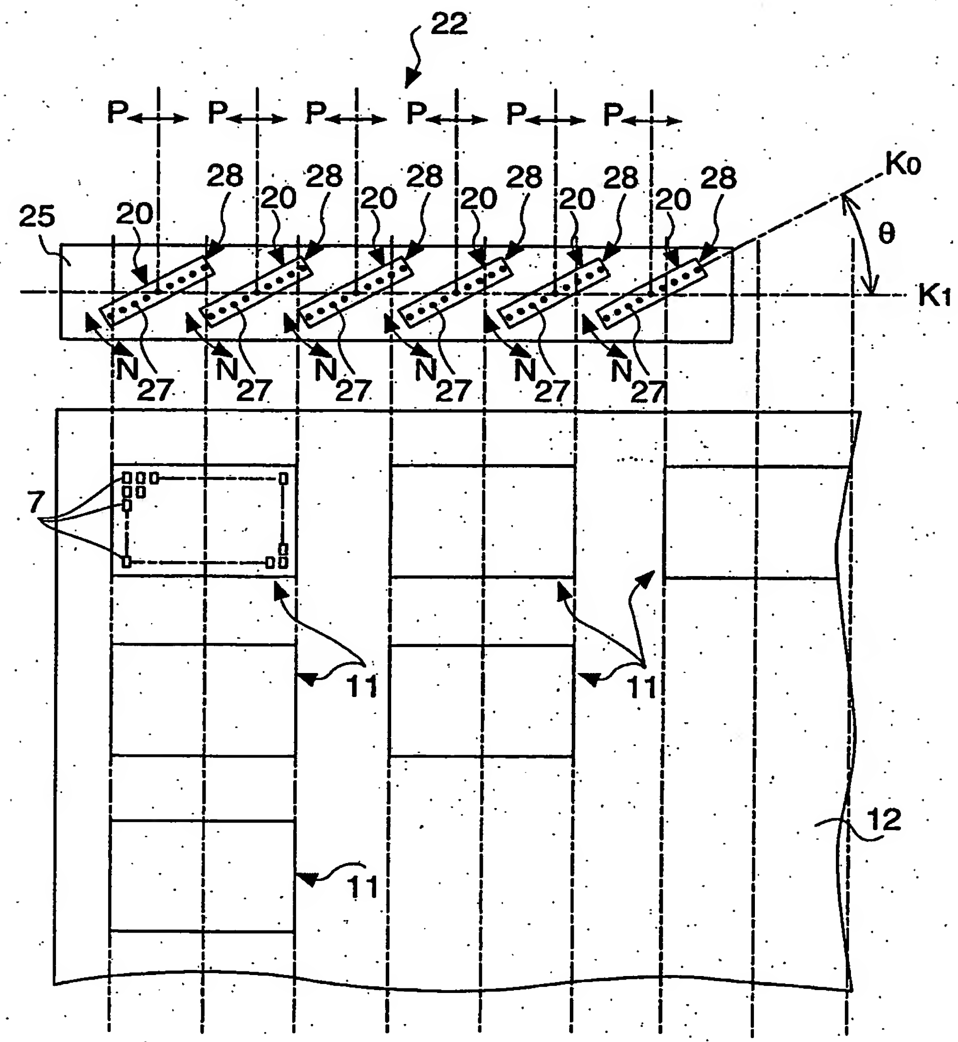


FIG. 2


22
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N
27
N
27
N
27
7
11
11
11
12

FIG. 3

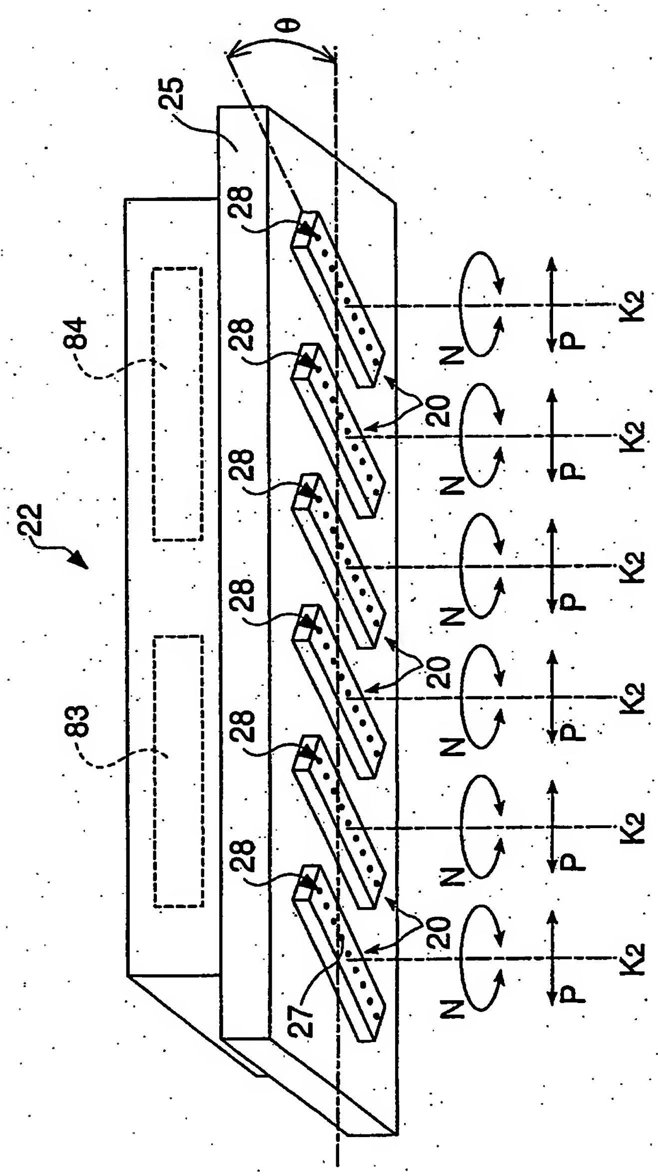


FIG. 4

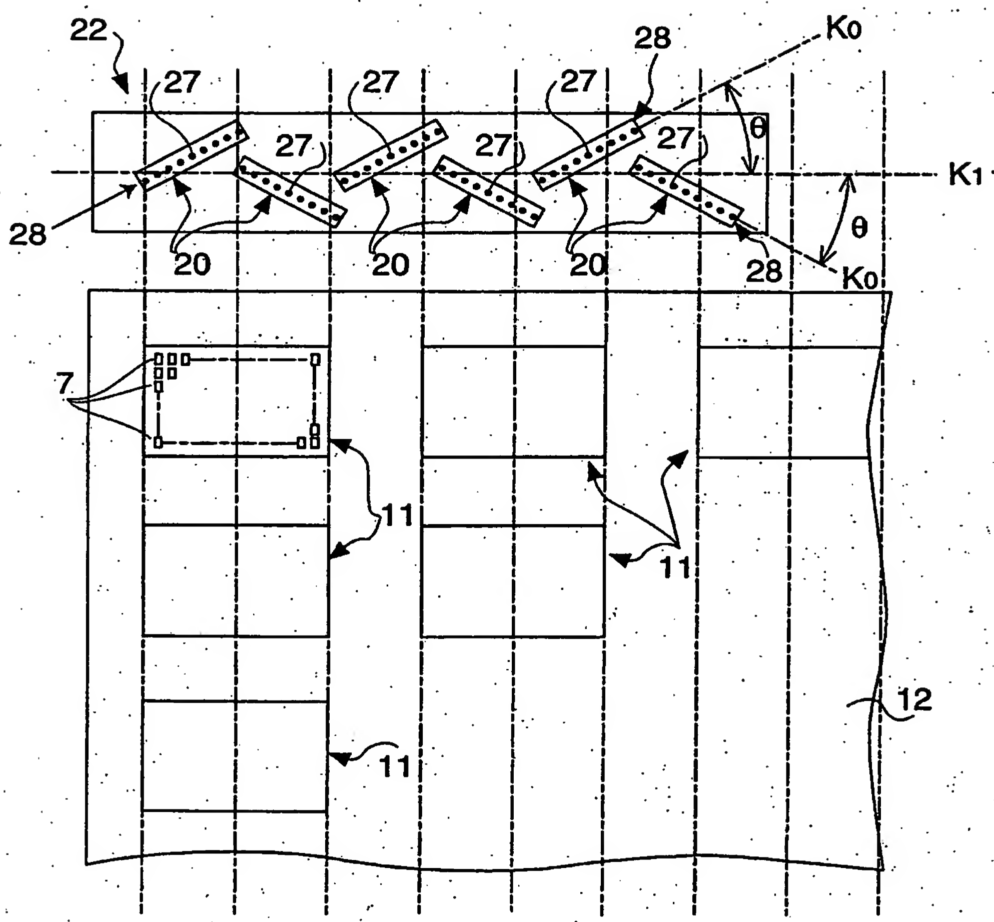
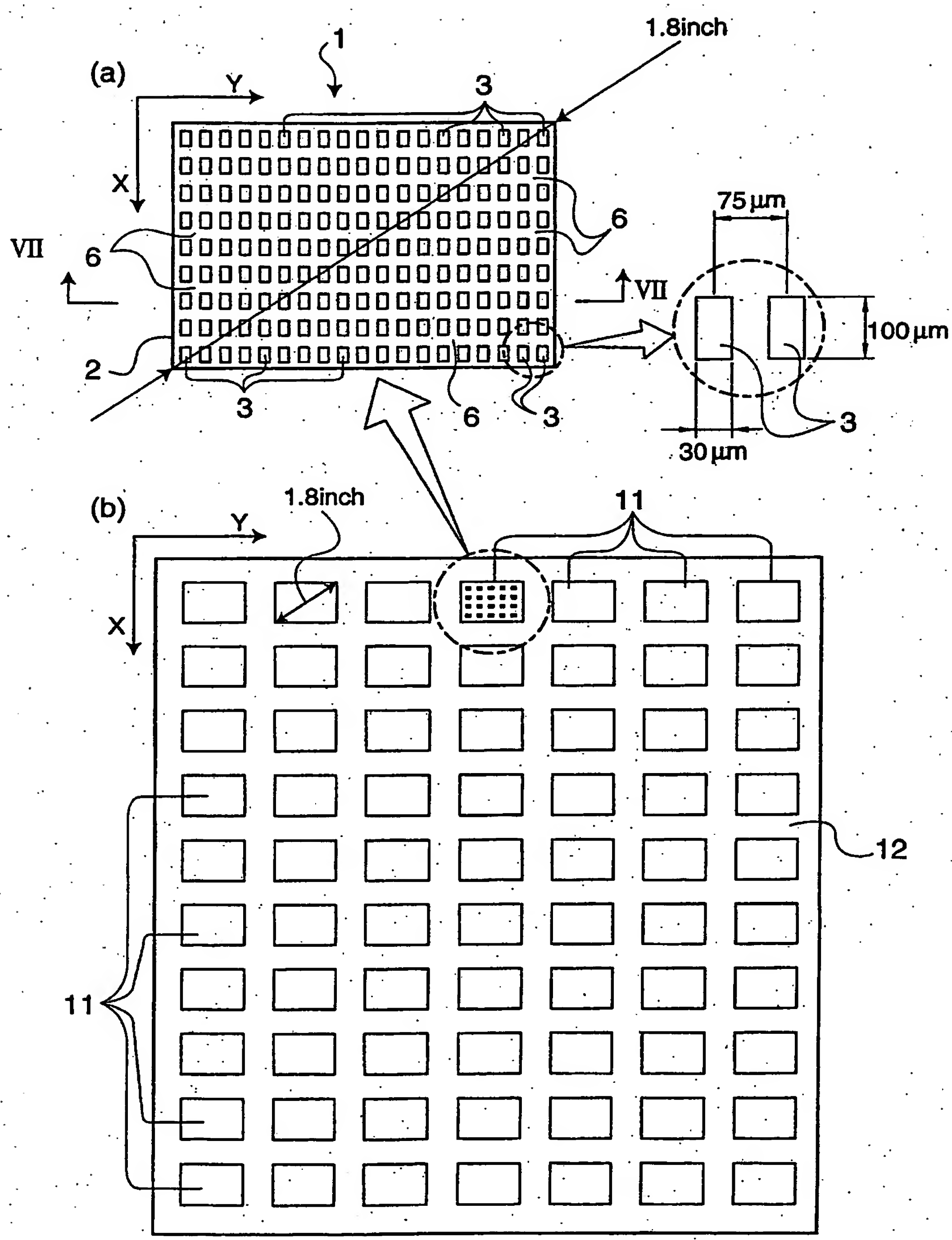


FIG. 5



(a)
1
1.8inch
Y
X
3
6
VII
6
VII
75 µm
100 µm
2
3
6
3
3
30 µm
(b)
1.8inch
11
Y
X
12
11

FIG. 6

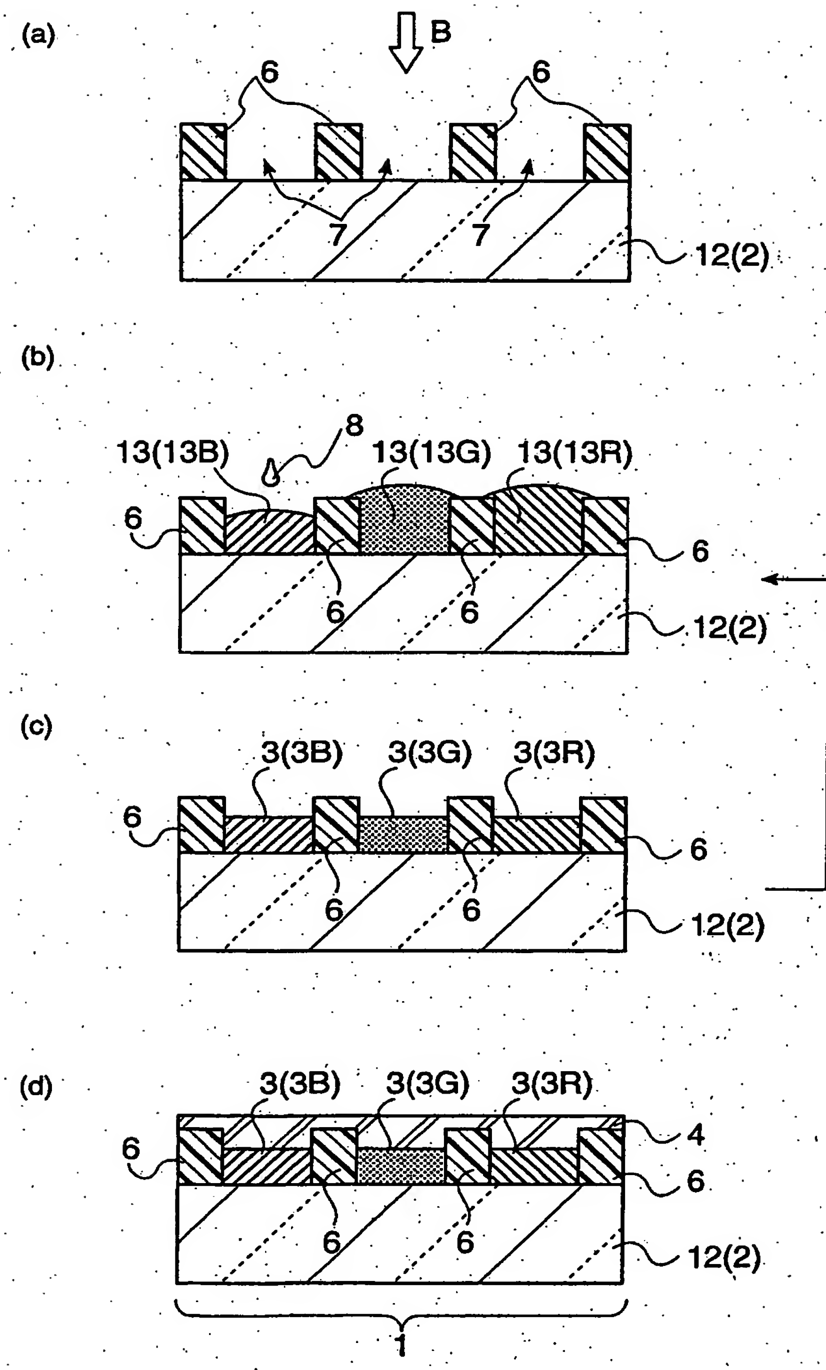

(a)
B
6
6
7
7
12(2)
(b)
8
13(13B)
13(13G)
13(13R)
6
6
6
6
12(2)
(c)
3(3B)
3(3G)
3(3R)
6
6
6
6
12(2)
(d)
3(3B)
3(3G)
3(3R)
4
6
6
6
6
12(2)
1

FIG. 7

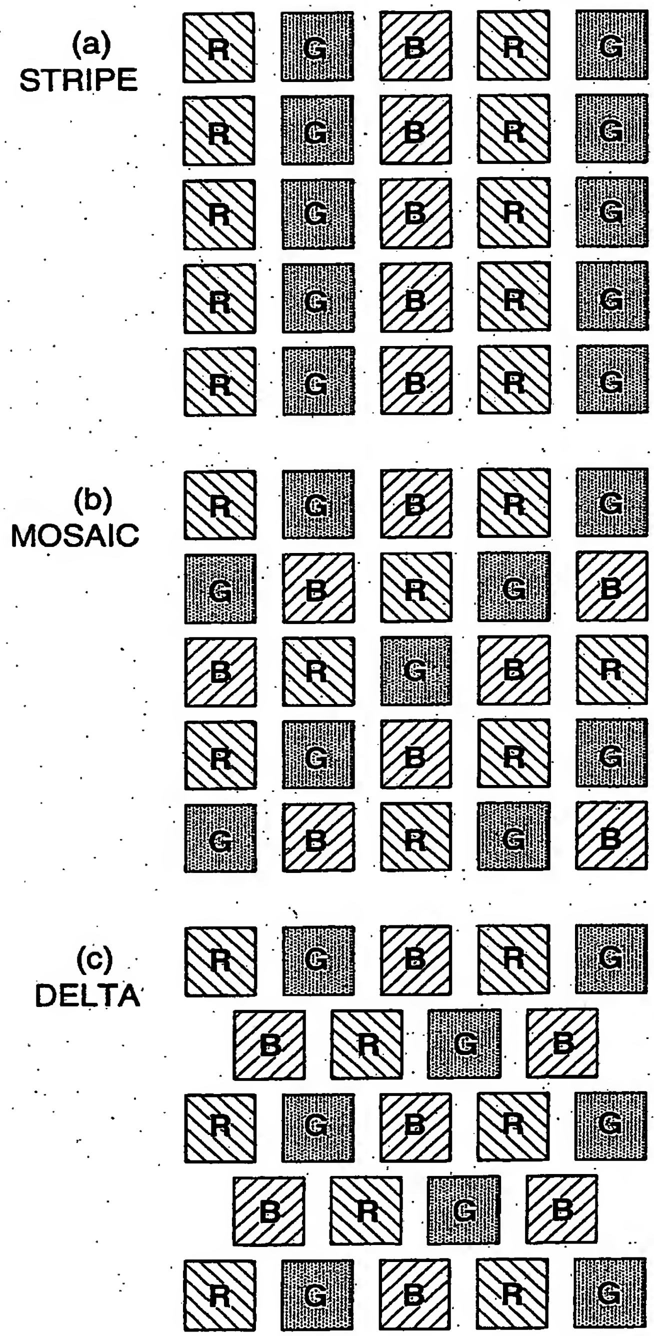


FIG. 8

BEST AVAILABLE COPY

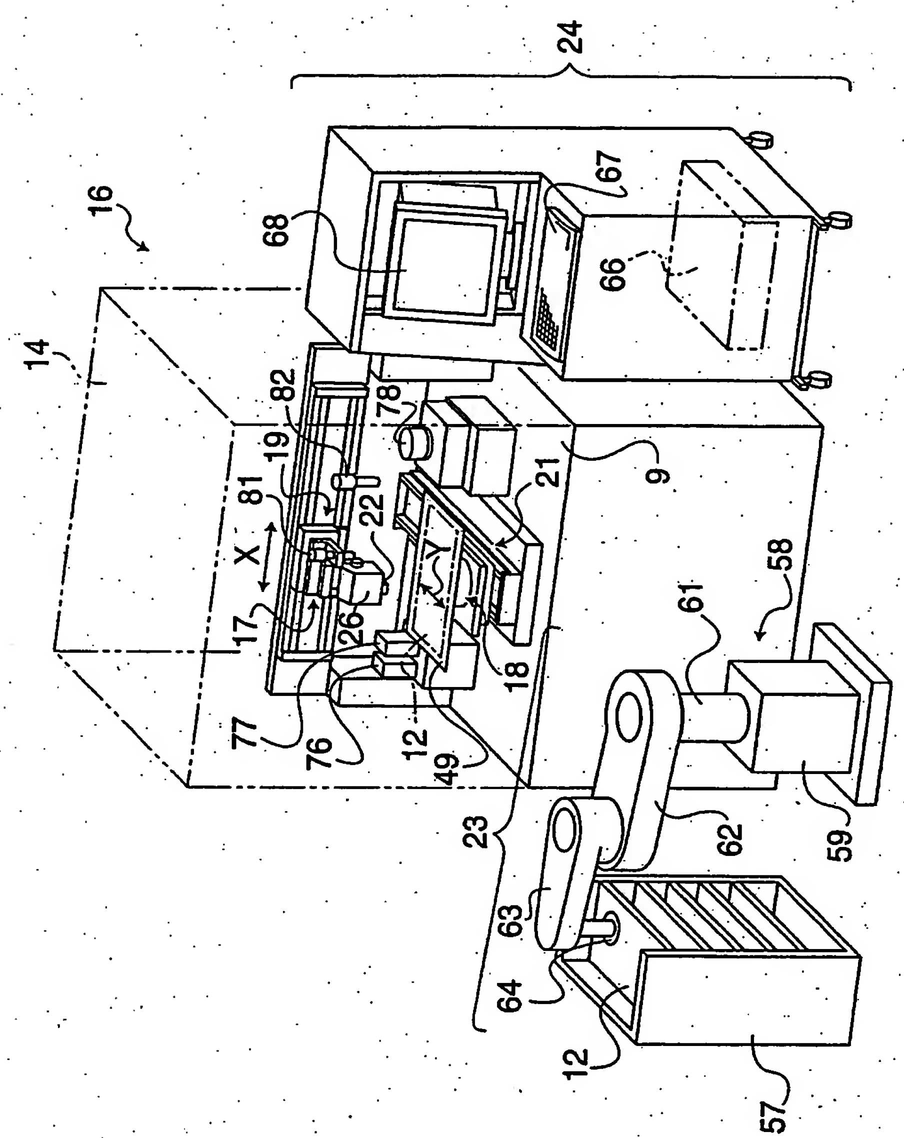

24
16
14
68
67
66
82
78
19
81
X
22
21
9
17
26
Y
18
77
76
12
49
23
61
58
62
59
63
64
12
57

FIG. 9

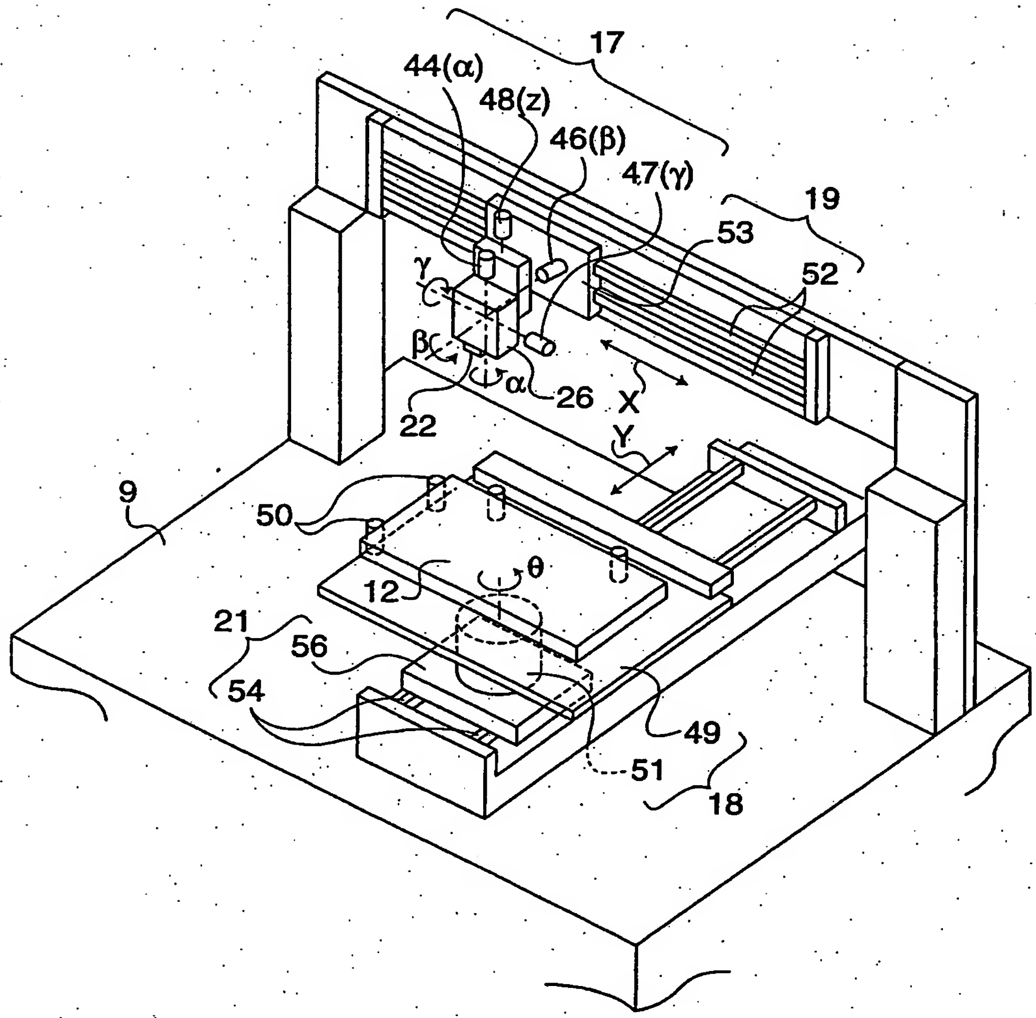


FIG. 10

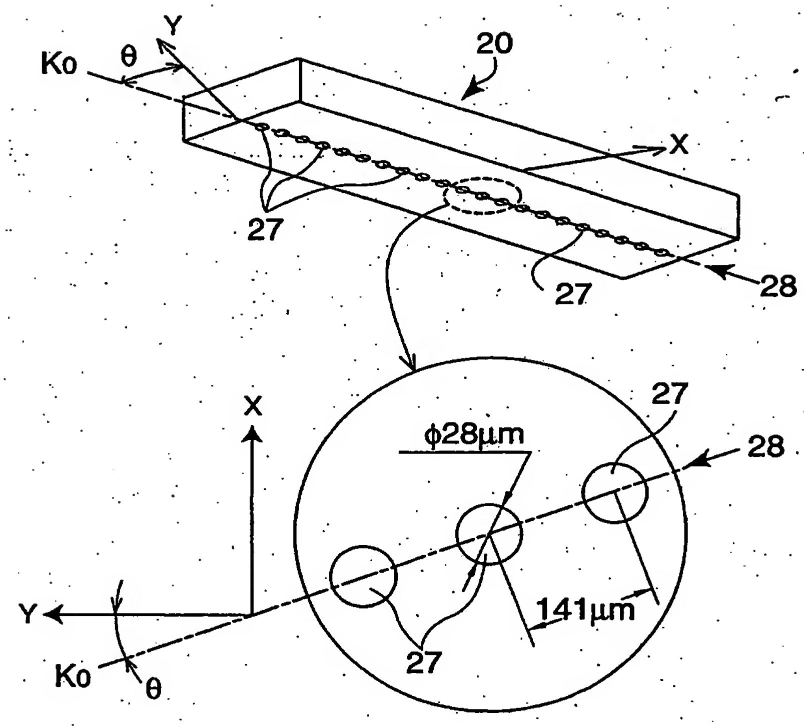


FIG. 11

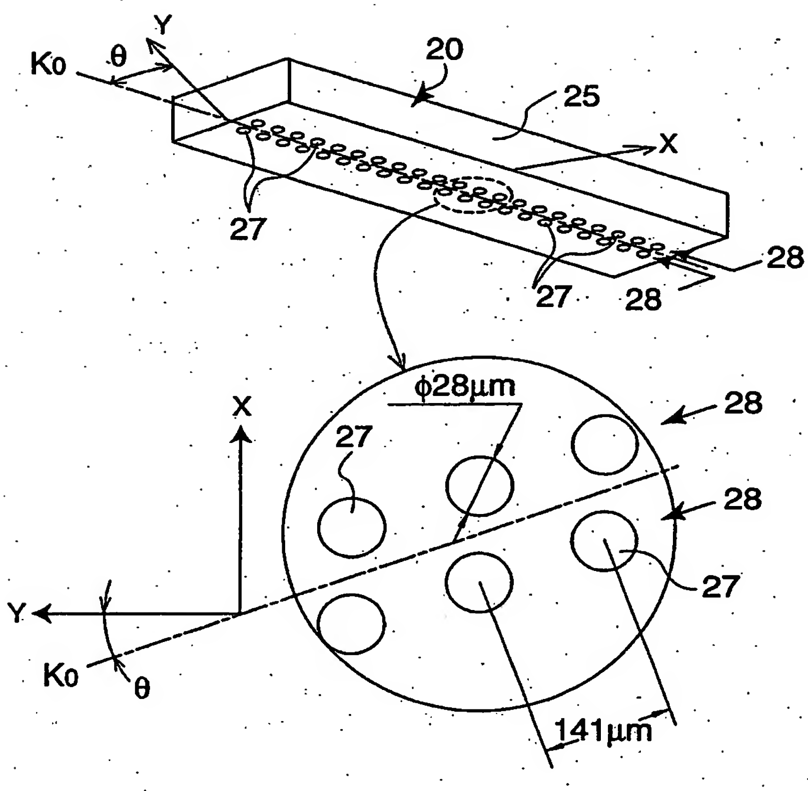


FIG. 12

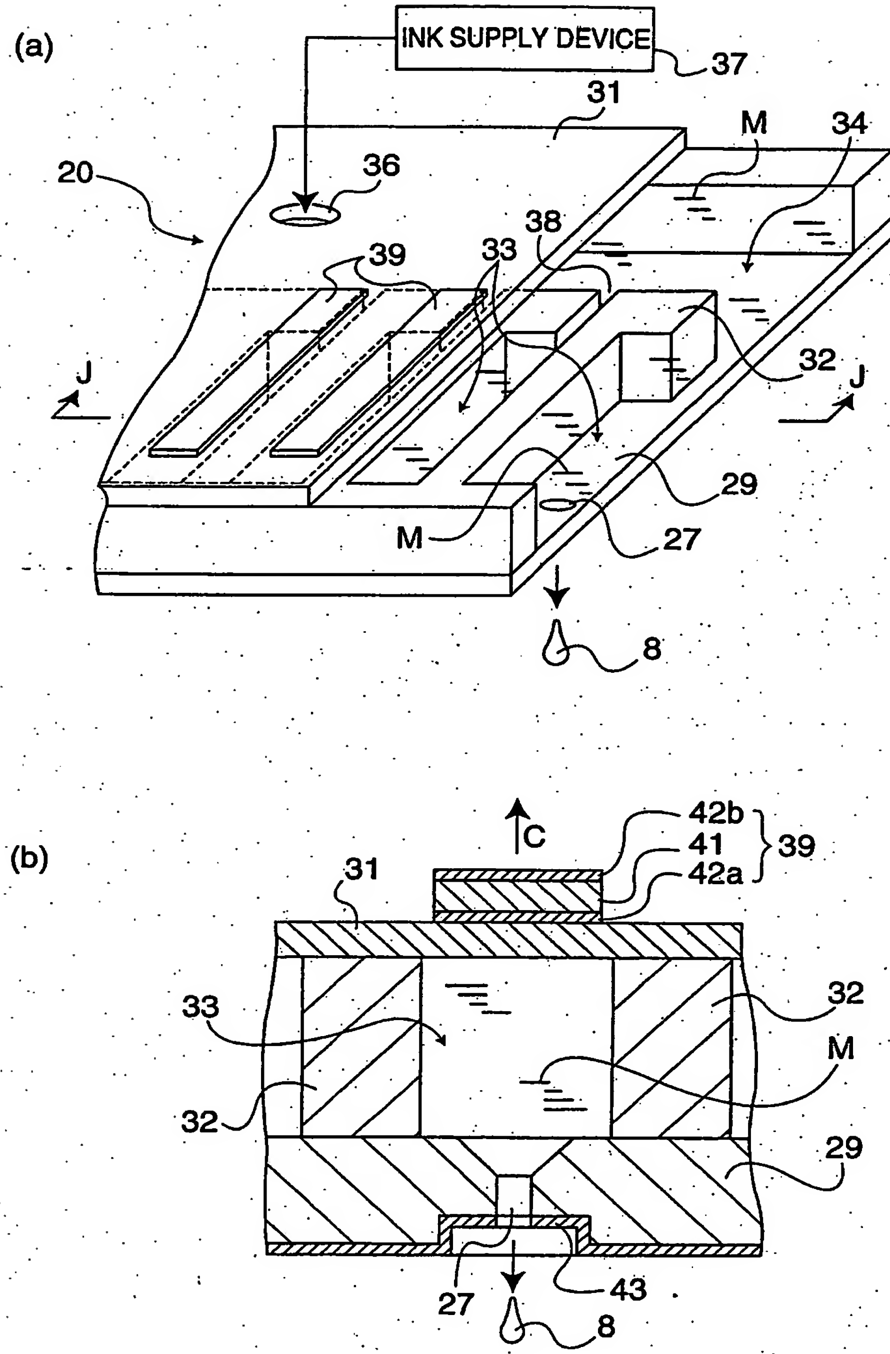
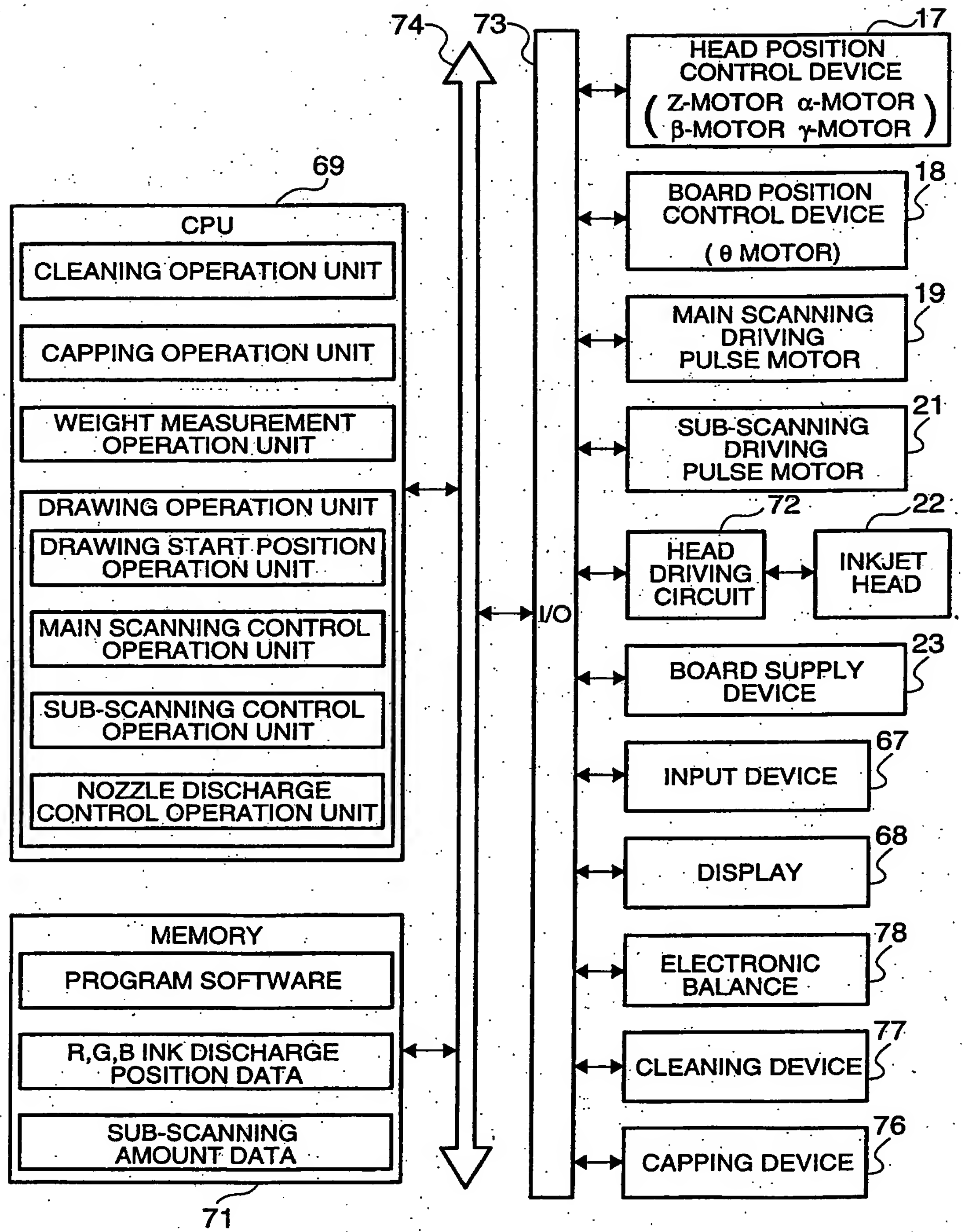


FIG. 13

BEST AVAILABLE COPY



74
73
17
HEAD POSITION CONTROL DEVICE
(Z-MOTOR α-MOTOR β-MOTOR γ-MOTOR)
69
CPU
CLEANING OPERATION UNIT
CAPPING OPERATION UNIT
WEIGHT MEASUREMENT OPERATION UNIT
DRAWING OPERATION UNIT
DRAWING START POSITION OPERATION UNIT
MAIN SCANNING CONTROL OPERATION UNIT
SUB-SCANNING CONTROL OPERATION UNIT
NOZZLE DISCHARGE CONTROL OPERATION UNIT
18
BOARD POSITION CONTROL DEVICE
(θ MOTOR)
19
MAIN SCANNING DRIVING PULSE MOTOR
21
SUB-SCANNING DRIVING PULSE MOTOR
72
22
HEAD DRIVING CIRCUIT
INKJET HEAD
I/O
23
BOARD SUPPLY DEVICE
67
INPUT DEVICE
68
DISPLAY
MEMORY
PROGRAM SOFTWARE
R,G,B INK DISCHARGE POSITION DATA
SUB-SCANNING AMOUNT DATA
71
78
ELECTRONIC BALANCE
77
CLEANING DEVICE
76
CAPPING DEVICE

FIG. 14

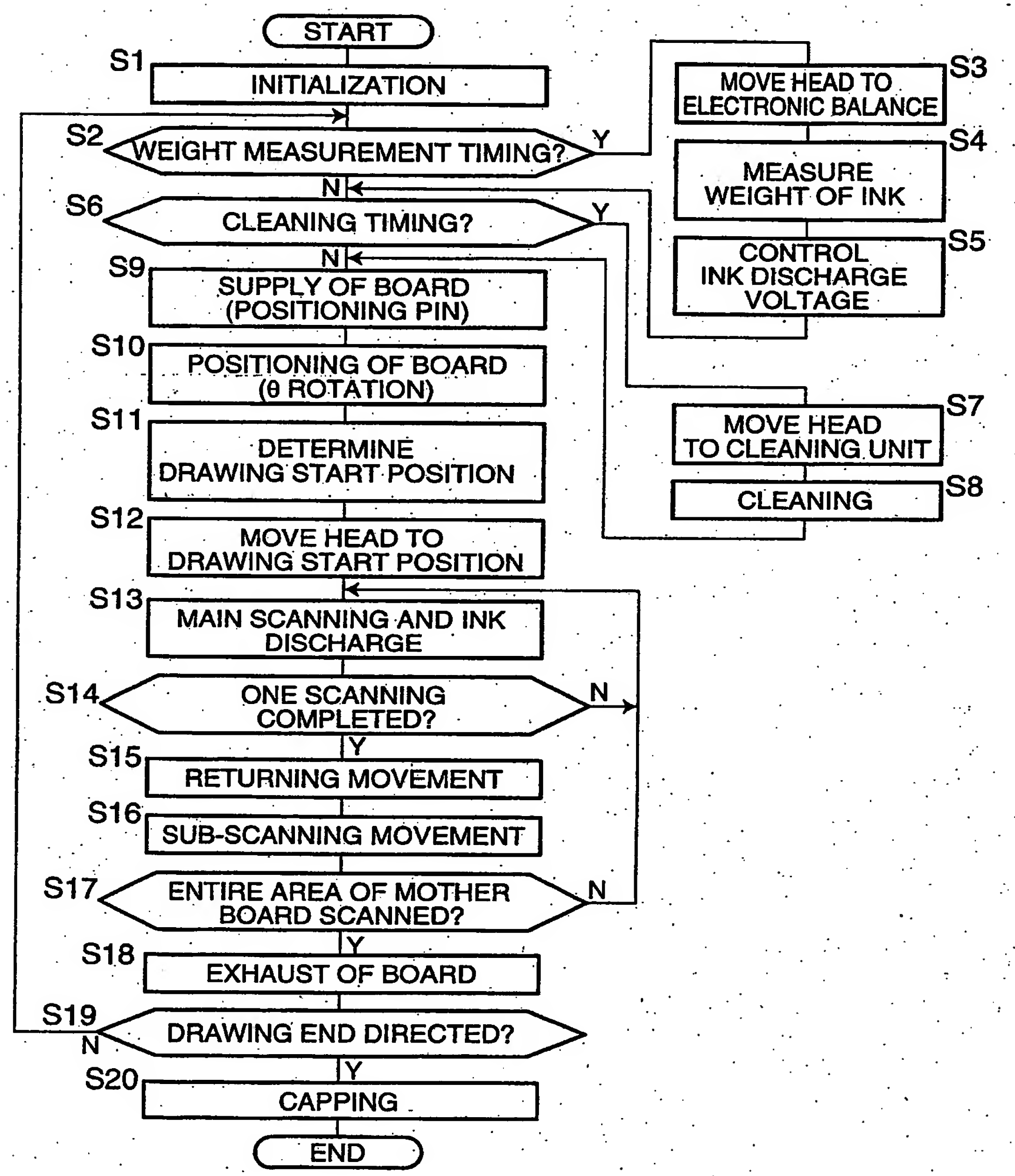
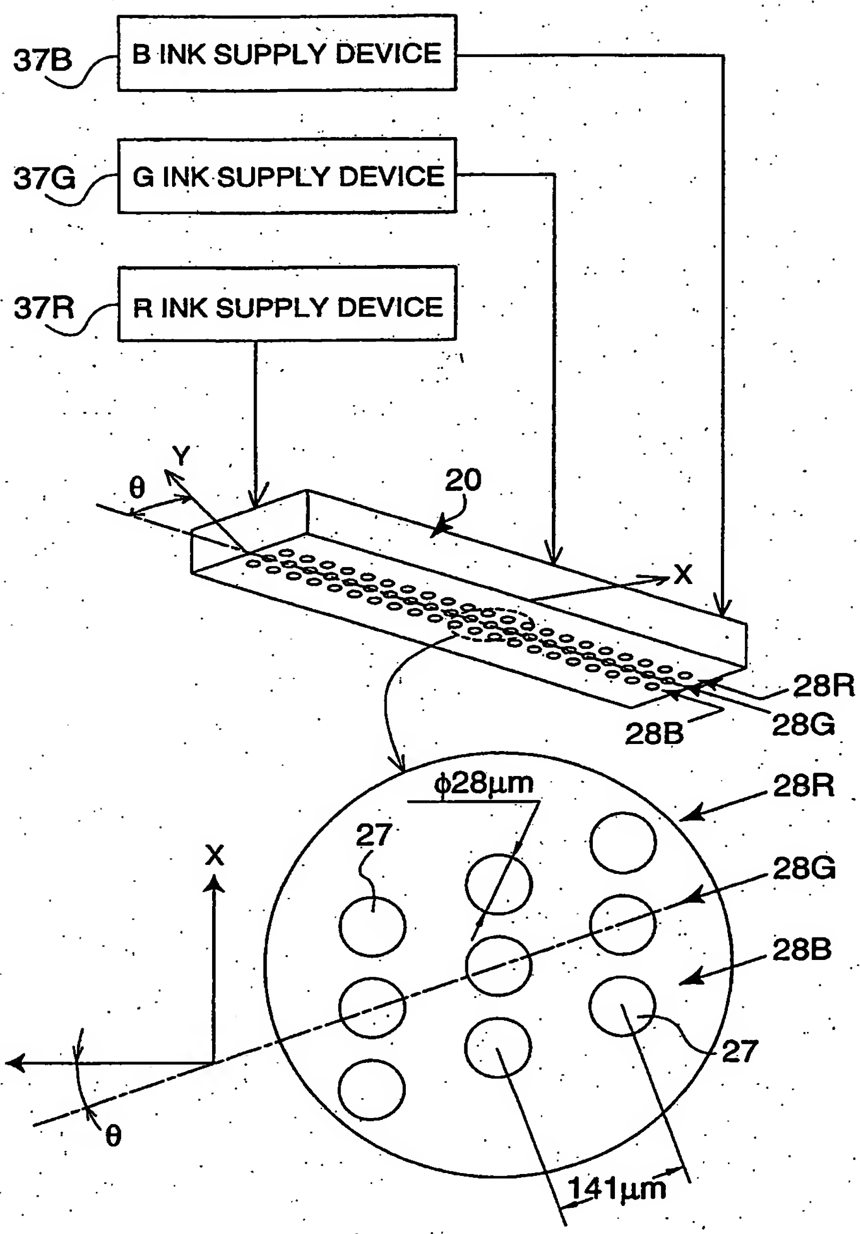

START
S1
INITIALIZATION
S2
WEIGHT MEASUREMENT TIMING?
Y
N
S3
MOVE HEAD TO ELECTRONIC BALANCE
S4
MEASURE WEIGHT OF INK
S5
CONTROL INK DISCHARGE VOLTAGE
S6
CLEANING TIMING?
Y
N
S7
MOVE HEAD TO CLEANING UNIT
S8
CLEANING
S9
SUPPLY OF BOARD (POSITIONING PIN)
S10
POSITIONING OF BOARD (θ ROTATION)
S11
DETERMINE DRAWING START POSITION
S12
MOVE HEAD TO DRAWING START POSITION
S13
MAIN SCANNING AND INK DISCHARGE
S14
ONE SCANNING COMPLETED?
N
Y
S15
RETURNING MOVEMENT
S16
SUB-SCANNING MOVEMENT
S17
ENTIRE AREA OF MOTHER BOARD SCANNED?
N
Y
S18
EXHAUST OF BOARD
S19
DRAWING END DIRECTED?
N
Y
S20
CAPPING
END

FIG. 15



37B
B INK SUPPLY DEVICE
37G
G INK SUPPLY DEVICE
37R
R INK SUPPLY DEVICE
Y
θ
20
X
28R
28G
28B
φ28μm
27
X
28R
28G
28B
27
Y
θ
141μm

FIG. 16

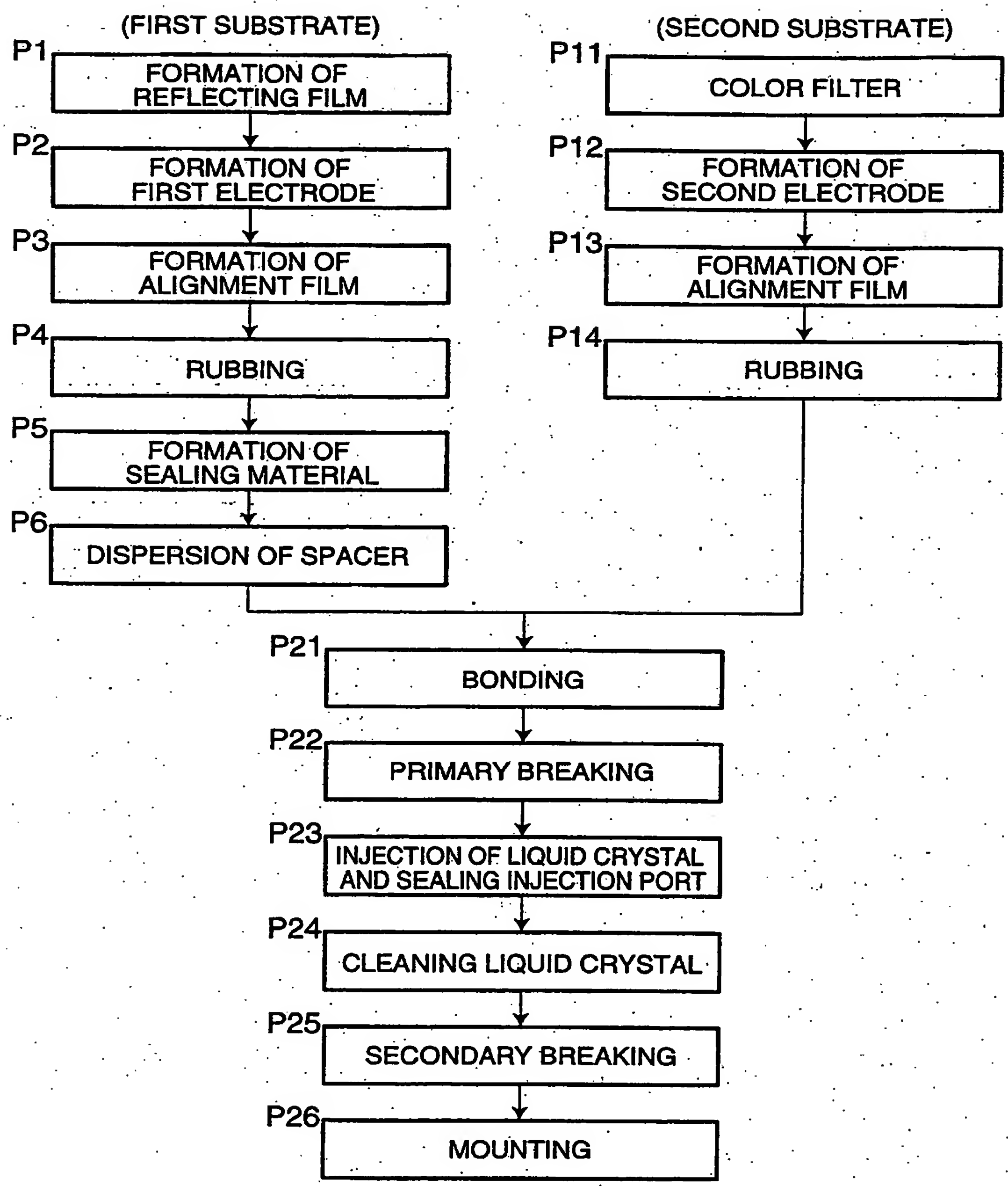

(FIRST SUBSTRATE)
P1
FORMATION OF REFLECTING FILM
P2
FORMATION OF FIRST ELECTRODE
P3
FORMATION OF ALIGNMENT FILM
P4
RUBBING
P5
FORMATION OF SEALING MATERIAL
P6
DISPERSION OF SPACER
(SECOND SUBSTRATE)
P11
COLOR FILTER
P12
FORMATION OF SECOND ELECTRODE
P13
FORMATION OF ALIGNMENT FILM
P14
RUBBING
P21
BONDING
P22
PRIMARY BREAKING
P23
INJECTION OF LIQUID CRYSTAL AND SEALING INJECTION PORT
P24
CLEANING LIQUID CRYSTAL
P25
SECONDARY BREAKING
P26
MOUNTING

FIG. 17

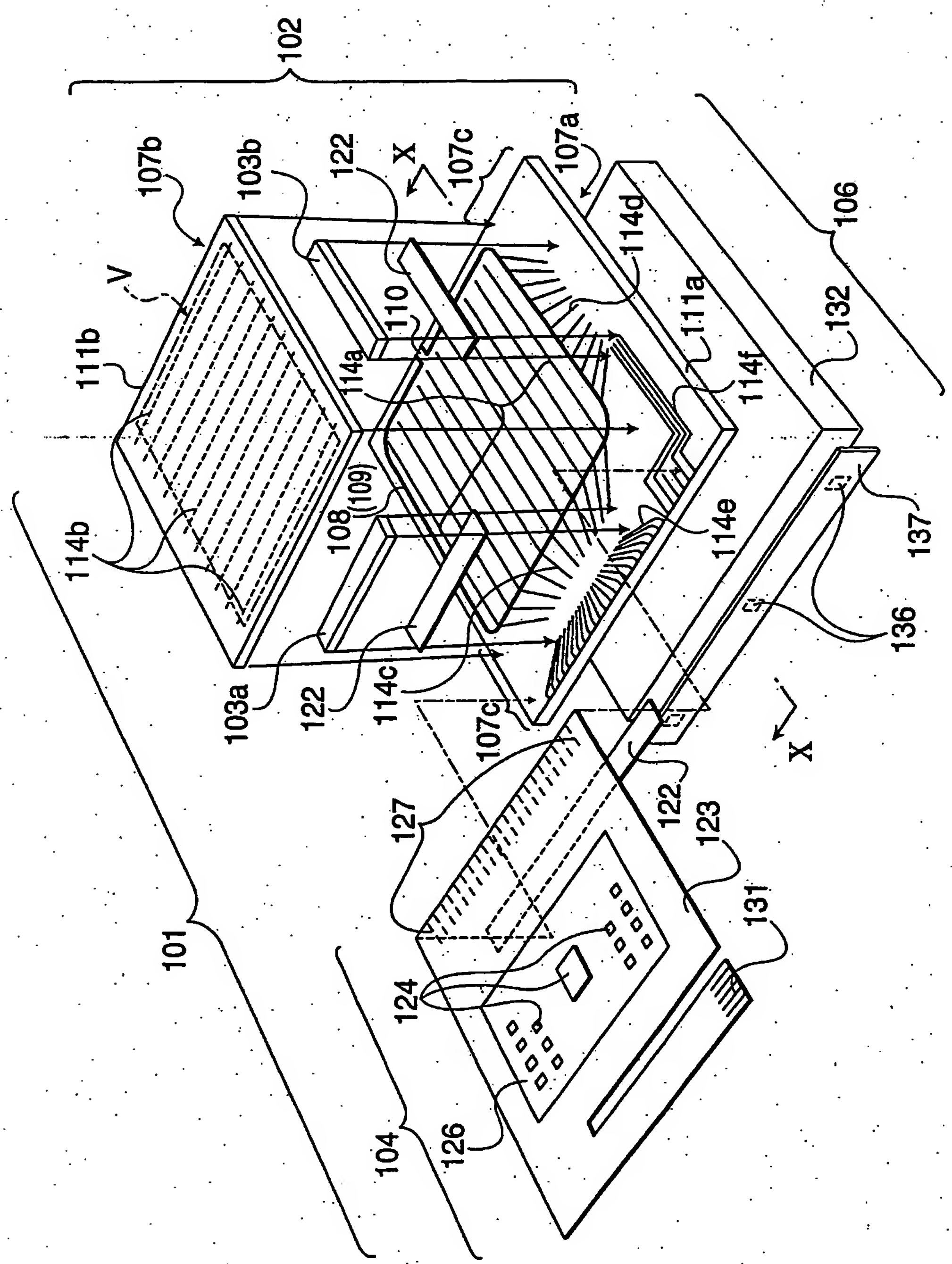

102
107b
103b
122
X
107c
107a
V
111b
110
114d
114a
111a
132
106
114f
114b
108
(109)
114e
137
136
103a
122
114c
107c
X
127
122
123
101
131
124
104
126

FIG. 18

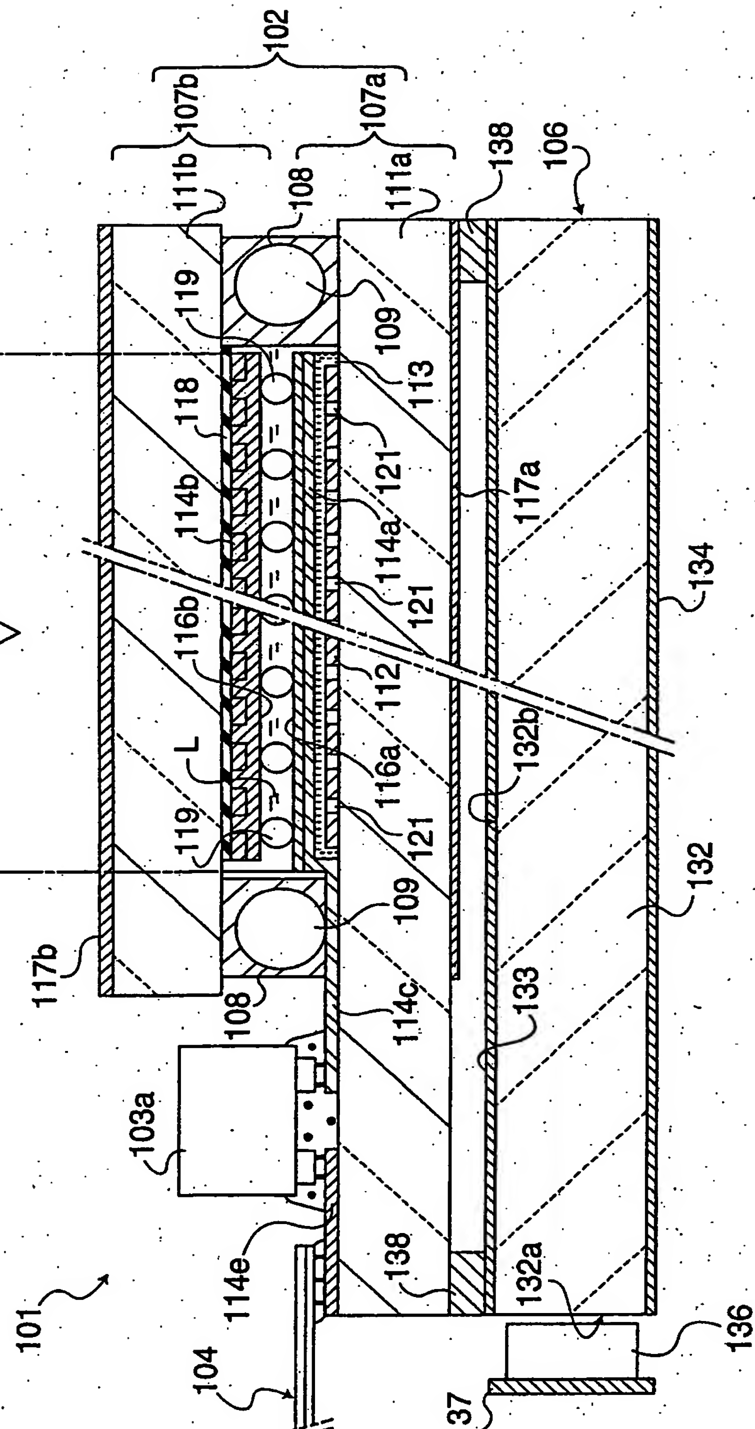


FIG. 19

BEST AVAILABLE COPY

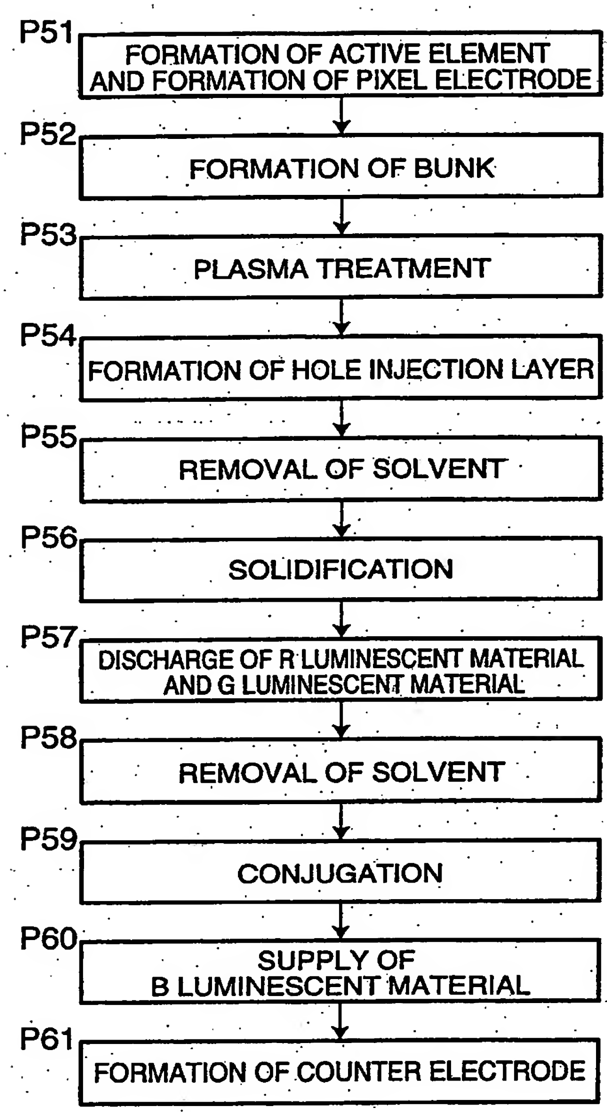

P51
FORMATION OF ACTIVE ELEMENT AND FORMATION OF PIXEL ELECTRODE
P52
FORMATION OF BUNK
P53
PLASMA TREATMENT
P54
FORMATION OF HOLE INJECTION LAYER
P55
REMOVAL OF SOLVENT
P56
SOLIDIFICATION
P57
DISCHARGE OF R LUMINESCENT MATERIAL AND G LUMINESCENT MATERIAL
P58
REMOVAL OF SOLVENT
P59
CONJUGATION
P60
SUPPLY OF B LUMINESCENT MATERIAL
P61
FORMATION OF COUNTER ELECTRODE

FIG. 20

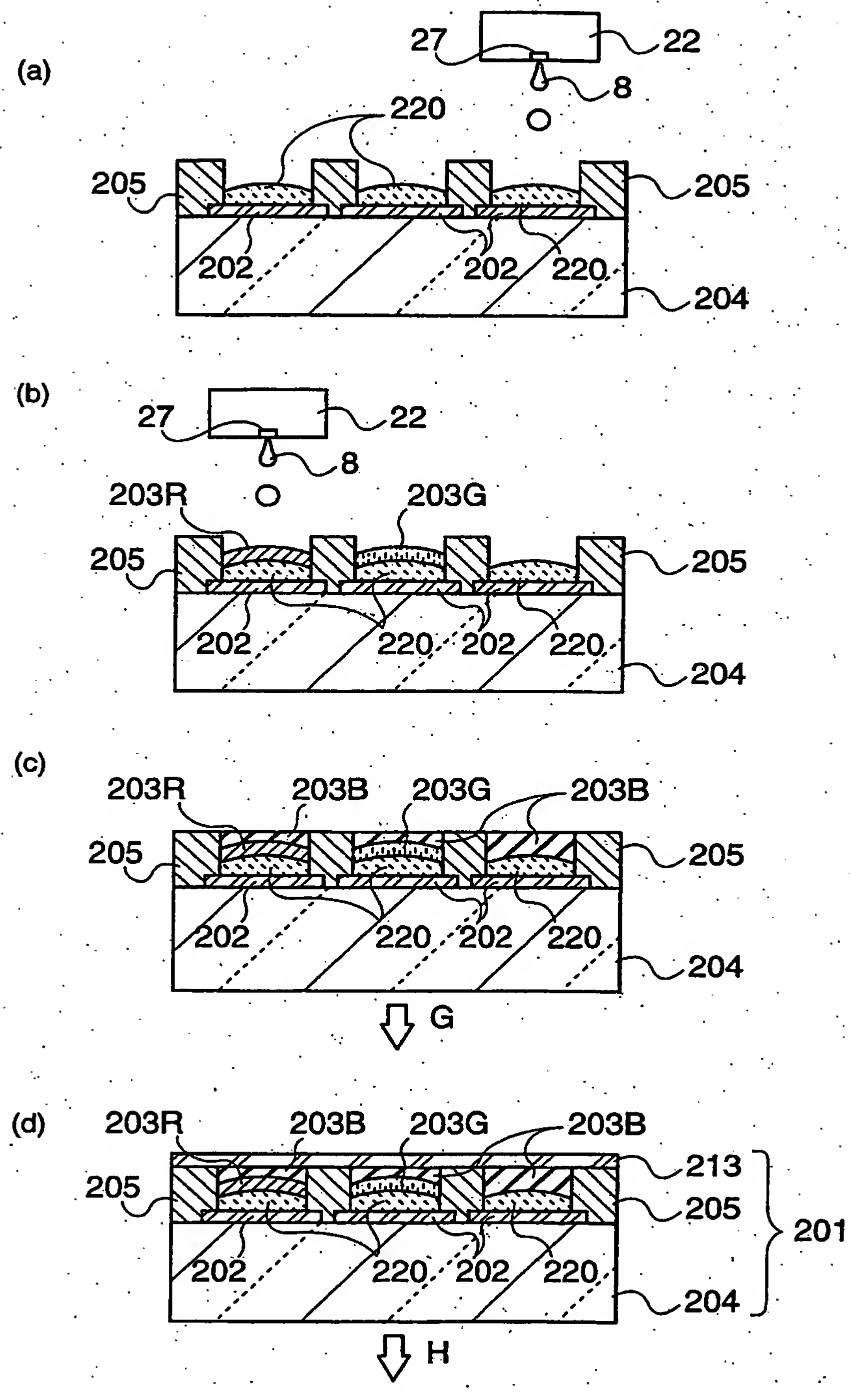

(a)
27
22
8
220
205
205
202
202
220
204
(b)
27
22
8
203R
203G
205
205
202
220
202
220
204
(c)
203R
203B
203G
203B
205
205
202
220
202
220
204
G
(d)
203R
203B
203G
203B
213
205
205
201
202
220
202
220
204
H

FIG. 21

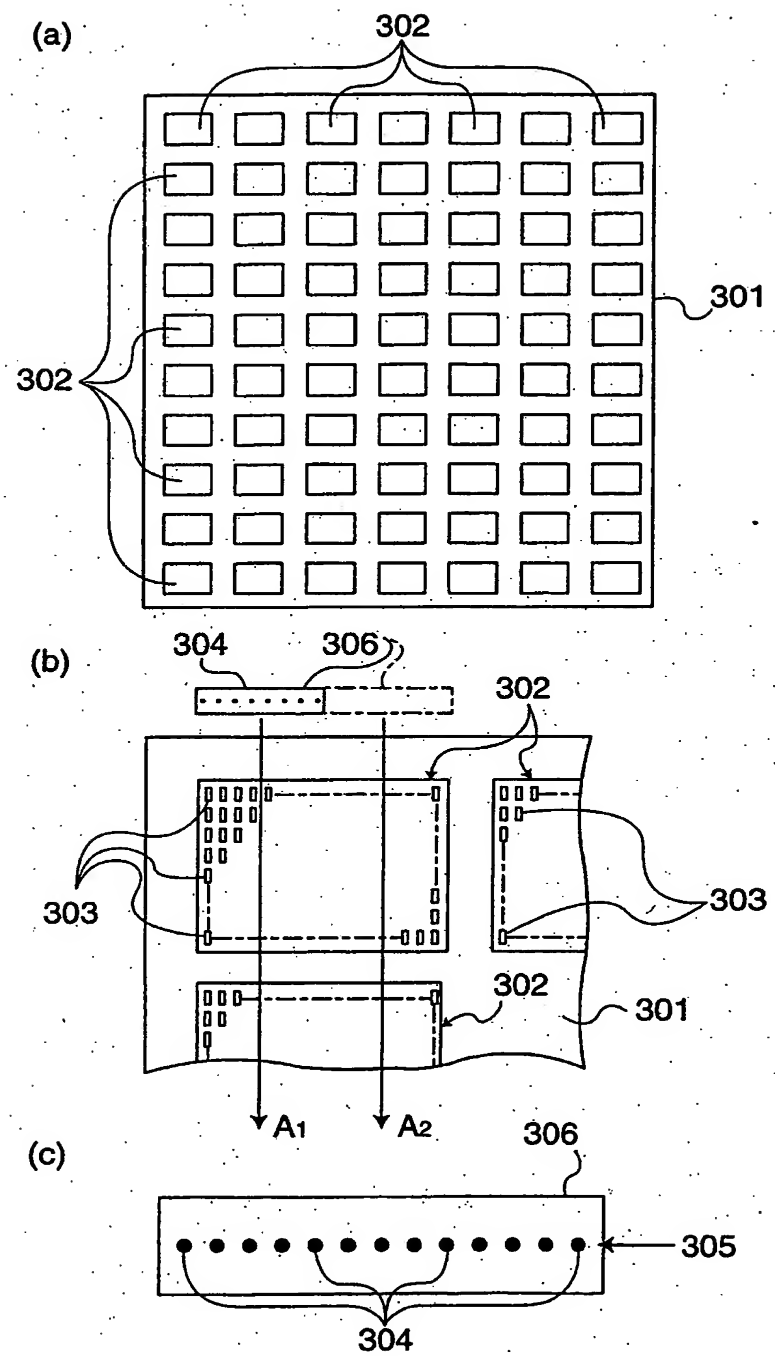


FIG. 22

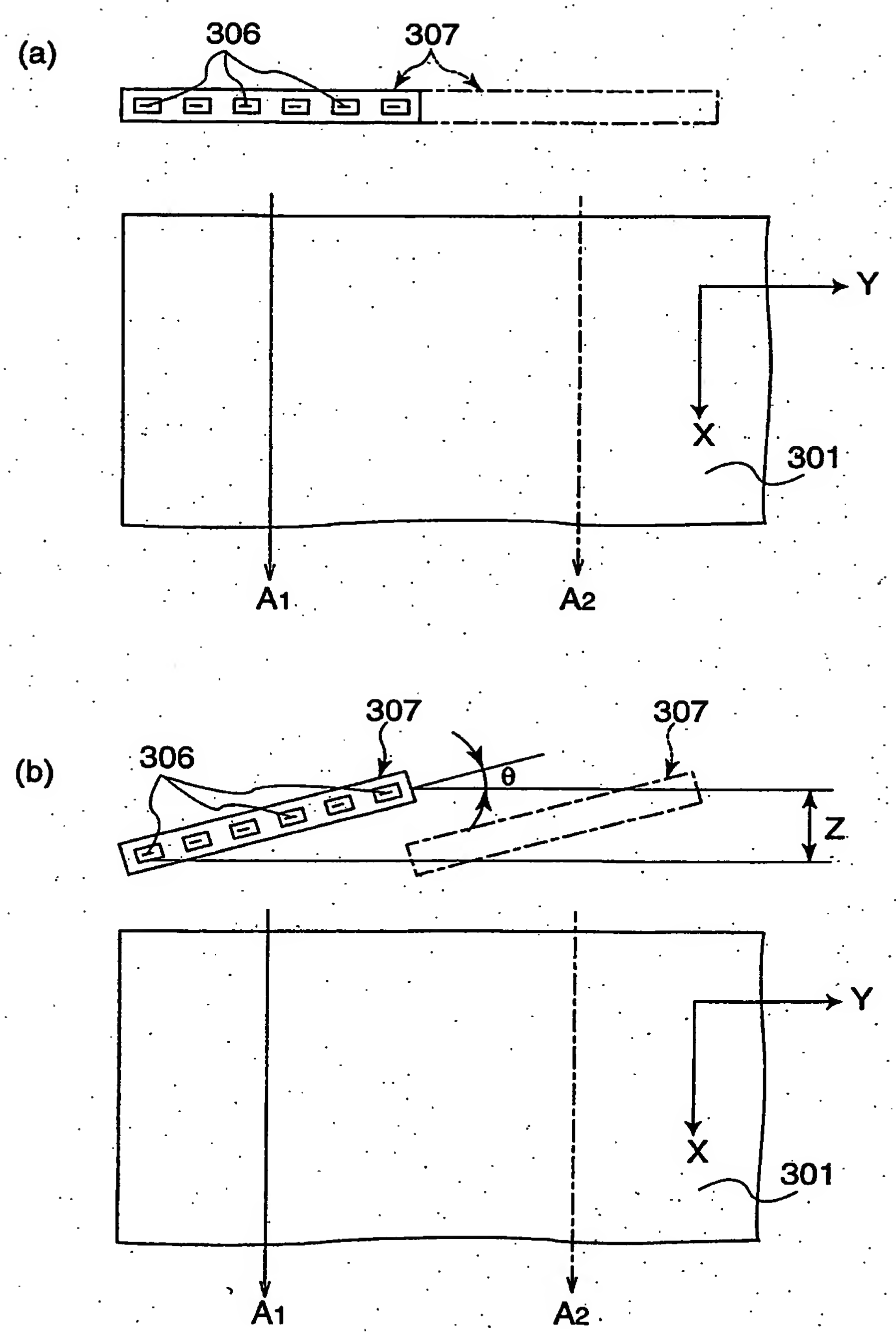


FIG. 23